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TOWNSMAN'S FOOD

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PREFACE

Only a committee of experts could be expected in the year 1951 to know enough to be able to write, with full authority, even in general terms, about the technicalities of a dozen different kinds of foods. This book, therefore, will probably betray shortcomings of knowledge or judgment. Yet specialisation leaves much of interest unsaid. Above all, it ignores basic motives. The food expert who specialises on jam knows precisely what temperature his brew requires and how much fruit pulp, acid and colouring matter are needed to produce a stable, sanitary comestible which will attain the official 'fresh fruit standard'. He is not, however, expected to understand anything about the part which a well-chosen meal can play in the good life.

Nevertheless, although the modern food expert may often be accused of exhibiting a narrow, specialist attitude, the intricate technical treatments by which foods are processed are in many instances essential for the maintenance of the complex diet of a civilised urban community. It is easy to feel romantic regret for the simple foods of earlier centuries, and at the same time to forget that spices were introduced into medieval Europe principally to mask the flavour of decayed meat. The housewife with the tin-opener may be a figure of fun for the cartoonist, but few reasonable people would wish to live without the many kinds of canned meat, canned fish or canned fruit which add variety to a modern diet.

We are naturally conservative about food and when one is conservative one is also suspicious. It is right for people to suspect danger from the addition of 'chemicals' to food. But when such substances have proved their harmlessness and their positive value, they should be welcomed as warmly as modern innovations in other realms of technology. Salt is accepted as a chemical nutrient, and the use of saltpetre as a preservative in bacon manufacture is hallowed by long usage. Today, several different groups of substances are knocking at the dietetic door. There are new preservatives, emulsifiers, colouring agents, flavours, flour 'improvers', anti-staling agents, sweetening agents, anti-oxidants and antiseptics. Not all of them are harmless; but when there is good evidence of the usefulness and safety of any one of them, we should be foolish to refuse to use it.

In this book I have tried to look at the busy world of modern food technology as a whole, not so much to provide the general reader with the details of processes and factory methods, but rather to attempt to show what has happened to 'civilised' food. In any such survey one quickly discovers the existence of two kinds of food scientists. On the one hand, there is the nutritionist, who calculates the adequacy of a diet in terms of numbers of calories, grams of protein, milligrams of calcium and international units of this or that vitamin. This type of food scientist points out, for instance, that there is more protein, say, in mince than in a joint of beef, and argues that the housewife's 'protein penny' should be spent accordingly on mince ; his concern is to weigh up the relative value of raw-cabbage salad, wholemeal bread and dehydrated egg. By contrast, the second kind of food scientist is not primarily concerned with the nutritional value of foods and their effect on health and energy. His province is the study of the chemistry of the commodities he handles, the best methods of preserving, transporting, packing, storing, colouring and flavouring them. He aims to produce an 'improved' loaf, a joint of 'prime' beef or canned peas of 'first grade' quality.

These two experts, the nutritionist and the technologist, have in their time found themselves in direct opposition to each other. Within recent years, however, there have been signs that each is beginning to understand that their two aspects of science are needed equally. The more intelligent nutritionists now appreciate that nutritional completeness and orthodoxy can be attained without requiring the consumption of specific 'health foods', while enlightened technologists realise that their business prospers best if the products they manufacture are wholesome as well as attractive.

It is the object of this book to try to describe for an intelligent, non-scientific reader some of the technical problems of modern food industry and to examine the aims and purposes of its techniques and policy.

M. P.

Cambus, Clackmannanshire
April, 1951

I

The Producer, the Scientist, and your Food

In order to feed the crowded numbers of a modern civilised community there must be a complex food industry, and the articles of food which it handles must be of such a quality that they will resist this necessary handling. It is easy to condemn food manufacturers and to complain that they do not 'manufacture' food but merely sophisticate it. But it is unfair to do so without giving consideration to the social service which is the manufacturer's reason for existence.

People who live on a large mixed farm can, if they wish, eat bread made from home-made wheat flour. It will possess certain differences in composition, consistency and taste from what is considered today to be a 'normal' loaf. Some of the differences can be argued to be improvements, but some are, beyond dispute, disadvantages. The people on the farm, if they have cream to spare, can also make their own butter—but not their own margarine or marmalade. They can eat their own beef, pork or mutton, but may have difficulty in supplying themselves steadily Sunday by Sunday throughout the year. They will not get any tea or coffee or cocoa nor, unless they live near the sea, will they have herring, cod, sole, whiting, lobster or oysters.

Consider the limitations in the diet which a countryman can produce for himself: it only needs a moment's thought to realise that it is essential to have a comprehensive and highly technical industry in being in order to make possible the functioning of the great urban aggregations of a modern industrial community.

This technical and complicated industry exists to serve two related but different purposes. First, the food industry has to keep the community alive and in tolerable health, just as the building industry shelters it from wind and rain. But in a civilised nation more than this is demanded both from houses and from food. To give satisfaction, even a 'pre-fab' must possess many endearing gadgets and plumbing of some aesthetic merit. Similarly a tin of 'luncheon meat' has a bland flavour, contains a useful contribution of protein, and is free from harmful ingredients. A cathedral is a product of the building industry just as much as a council house, and a banquet of rich foods—Bisques and Frivolities and kingly pies from which live singing birds fly up—is equally a product of the food trade. Neither the one nor the other is often essayed in these days of austerity; nevertheless it has to be recognised that the food industry must, as its second reason for existence, please as well as nourish.

The food supplies of big urban centres are influenced today by the possibilities of transport and storage and by the need to provide the quality and variety which civilised communities have come to demand. The combinations of food required for a nutritionally adequate diet are very simple. In 1942, Professor McCance worked out for the Medical Research Council an adequate skeleton diet upon which the British population could have healthily subsisted throughout the war years, and which would have greatly economised the national need for agricultural land and food imports. This 'siege' diet was based on brown bread, milk and vegetables; and the single-minded scientific workers who devised it supported themselves on it during a long and arduous experimental period. No normal community, however, would have accepted it without the most stringent compulsion.

Each of the different categories of food in the modern British diet presents a technological problem of its own. Thus each kind of food must be 'processed', 'handled', 'preserved', 'sophisticated' or 'improved' (use which word you please) before it finally reaches the person who is to eat it. Bread is made from wheat imported from Canada, Australia or South America, as well as from home-grown grain. The wheat may be a year or more old before it leaves its country of origin. While it is in storage it needs fumigation. Again, the milling of the quantity of grain needed to feed fifty million people is an enormous undertaking. The separation of the flour from the husk is not easy, and the storage of the milled flour vastly more difficult than the storage of the original wheat.

The supply of meat to an urban community presents as many problems as the supply of bread, and many of these problems have only been solved within comparatively recent years. Cold storage is a major engineering feat, and the chemistry of the meat held in cold storage is a complex study of itself. The technology of meat shows the dichotomy of food science in a striking manner. Books on dietetics advise the housewife—and the advice is accurate—to buy the cheaper cuts of meat in order to obtain many more grammes of protein per penny. This is one aspect of the science of food. On the other hand, the Food Investigation Board of the Department of Scientific and Industrial Research at Cambridge studies how to transport chilled meat from Australia in such a way that it shall be in 'prime' condition when it arrives in Britain. Here the scientific emphasis is on the 'primeness' and not on the protein.

Each commodity, in fact, presents its own problem in technology, and it is the same in food science as in all other branches of science today: the amount of technical detail has become so great that a specialist is required for each aspect of the subject. The ordinary citizen who eats the food which is handled by the specialist knows nothing of the reasons why it is treated as it is. If he is of an inquiring turn of mind he sometimes feels suspicious. In many instances his suspicions are unfounded; in other cases it is arguable that what is done is not, in truth, to his benefit.

The true purpose, however, of food technology is three fold: first, to make it possible to assemble the great quantities of food required by a crowded population; secondly, to make that food as agreeable as may be to eat; thirdly, to maintain or improve its nutritional value, and hence the health of the consumers.

A good deal of thought has recently been given to the meaning of 'health'. Dr. Johnson's dictionary says that 'health is the state of being hale, sound or whole, or freedom from sickness, pain or disease'. Or that it is 'welfare of mind, moral wellbeing, a state of salvation, purity, goodness or Divine grace'. The World Health Organisation did not depart from this definition as widely as might have been expected when, at a meeting in May, 1950, it defined health as 'a state of complete physical, mental and social wellbeing'. This then is the object towards which the third of the three aspects of food science is working.

During the first fifty years of the twentieth century, great advances occurred in the scientific understanding of the nature of food and in detailed knowledge of the requirements of different categories of people in the way of the diverse nutrients of which foods are composed. Where this knowledge has been applied, substantial improvements in public health have occurred. Simultaneously with the increase in understanding of nutrition, equally rapid developments in medical knowledge, agricultural productivity, sanitary engineering and economic justice have also taken place. All of these bear so intimately on health that it is difficult to disentangle the effect of one from that of the other. Part of the improvement in the figures for infant and maternal mortality can be attributed to better feeding, but it is impossible to say how large a part. There is also no doubt that good food makes young people grow more quickly, and it is fashionable nowadays to take pride in the fact that children are bigger than they used to be. The difficulty here, however, is to know whether this can be claimed as a net gain in view of the fact that the size of mature British adults has not altered in a hundred years. Nevertheless, the weight of evidence supports the conclusion that the physique and state of health of the nation have been improving from generation to generation. The expectation of life is certainly greater, and the incidence of disease less. Part of these gains can, very tentatively, be attributed to better food.

In the first two decades of this century there was a rapid surge of discovery in food science. The most striking aspect of this advance was the discovery of vitamins. This 'newer knowledge of nutrition' as it was called, caused great enthusiasm among those who immersed themselves in it. The most dramatic achievement of the new knowledge came, in 1922, when Dame

Harriet Chick, a biochemist, and her colleagues in a children's hospital in Vienna, triumphantly demonstrated that vitamin D was an effective treatment for rickets.

The science of nutrition can now claim many solid victories. The discovery of the cause of a number of deficiency diseases has enabled them to be dealt with effectively. Scurvy, for instance, has become a rare condition in all parts of the world and today is never seen even in ship's crews or exploring expeditions. It can be prevented by vitamin C, and vegetables, potatoes and greenstuff which contain vitamin C are readily available almost everywhere. Beri-beri is a serious and killing disease in many parts of the East. In 1897, the Dutch investigator Eijkman, working in Java, discovered that rice-polishings, containing what is now known as vitamin B_1, prevent or cure beri-beri. In places where this knowledge is applied, fewer people die of beri-beri today than in 1897, though the disease is still a public health problem in countries in which it has always been endemic.

Another B-vitamin, nicotinic acid, plays a big part in the prevention of the disease pellagra. Here again, however, the victory is not complete and the disease, although reduced in incidence, still takes its toll of life and health even in so advanced a country as the United States. Another disease, xerophthalmia, can be caused by vitamin A deficiency. Red palm oil is rich in vitamin A activity and can be used for the effective treatment of xerophthalmia, still widespread in many parts of Africa.

Thus it can be said that in instances where people eat inadequate diets they may develop one of several recognisable deficiency diseases; and the food components necessary to prevent and cure these diseases are now known. It is worth considering, however, to what extent the food technologist can use this knowledge to benefit people's health in, say, Britain or other 'high standard' countries. Here the only clear and unequivocal evidence of advantages achieved relates to children and expectant mothers—thanks largely to the ampler provision of milk. Leaving aside for the moment the prevention of gross adulteration and infection, it is difficult to show that conscious scientific manipulation of food has effected any improvement in the health of the adult population in Britain during the last half century or so. The facts are most clearly shown from the work of two prominent investigators, Mr. Seebohm Rowntree and Lord Boyd Orr.

Mr. Rowntree studied the working-class population of York, first in 1899, and again in 1936. He concluded that below a certain income level, which he called the 'poverty line', people could not afford to buy enough to eat. When he divided his population into three groups according to income, the poorest had the highest death rate and the highest infant mortality rate, and their children were shortest and lightest, both in 1936 and 1899. Lord Boyd Orr in his report, written in 1937, on a sample of 1,152 families scattered over the whole country, also concluded that poorer people ate a less satisfactory diet than those with more money; and he, too, presented evidence to show that the children in poorer families were smaller than those in better-to-do households. Tuberculosis mortality was nearly three times as high among unskilled labourers as among business and professional people. Both these surveys seem to suggest that, where ill-health is partly due to malnutrition, the composition of the food is less important than the possession of sufficient money to buy enough.

A number of things have been done for nutritional motives to individual foodstuffs. Vitamin A is added to margarine although clinical signs of vitamin A deficiency in Britain are rare. The inclusion of vitamin B_1 in bread has been extensively discussed, yet beri-beri is never seen. The campaign to promote the eating of green vegetables is designed to get more vitamin C into the diet; yet scurvy is a medical curiosity in Britain. We shall discuss each of these matters in detail in its proper place.

Meanwhile there is another aspect of the influence of food on health which ought to be put into focus before we turn our attention to individual foods. The gain in the nutritional state of British children as a result of ample supplies of milk is one of the triumphs of modern social medicine. But it is a moot point whether, even if the number of cows could be increased to meet the need, a milk distribution scheme on British lines would benefit infant welfare in, say, China. The nutritional value of milk is obtained to advantage in Britain only because it is comparatively free from infection. The battle for safe food is never won outright, however, and modern technical developments often increase the hazard. For example, the production of dried egg brought with it the problem of controlling the spread of food poisoning due to Salmonella infection which, while limited in its power to do harm when restricted to a single egg, becomes a danger when the one egg is processed with a thousand others. It is salutary and humiliating to remember that almost 1,000 outbreaks of food poisoning due to bacterial contamination of one sort or another were reported in England and Wales in 1948, compared with 500 in 1945 and a yearly average of 125 between 1935 and 1938.

We have taken the improvement of health as the third object of modern food technology. It is difficult to assert positively what should be done to achieve a general improvement in nutrition by changing the composition of individual foods when the best available evidence shows that better health follows a mere increase in purchasing power. Nevertheless, considerations of health (remembering the broad definition of health we are accepting) lead inevitably to the second object of modern food processing—the maintenance and improvement of quality.

Quality standards in food are necessarily relative. When the prison governor visits the prison kitchen to inspect the day's rations, which in British jails are each day ceremonially laid out for his approval, his standard for a 'good' dinner is different from the judgement he applies when the head waiter of his favourite restaurant brings for inspection a specially ordered dish. There is nothing positively harmful in a sausage containing only 30 per cent. of meat. Nevertheless, it would generally be considered to be of poor quality. Similarly, there is a recognisable difference in quality between good home-made jam and the official 'full fruit standard'.

One thing can be safely said: there is a relationship between national health and the proportion of meat, eggs, fat and other of the more expensive foods in the diet, compared with the proportion of cereals and potatoes. For example, in 1938 in a high-standard country such as New Zealand or Canada, where 60 per cent. to 70 per cent. of the national calories were derived from foods other than cereals and potatoes, the average expectation of life was 60 years for men and 64 for women. In a group of countries including, say, France or Czecho-Slovakia where only 40 per cent. to 50 per cent. of the calories came from non-cereal-and-potato foods, the average expectation of life for men was 52 years and for women 55 years. Expectation of life is admittedly a crude and uncertain index of nutritional health but the relationship is at least of circumstantial interest.

Now sausages, to take an example of a single manufactured food, are one of the forms in which meat is introduced into the diet. It can, therefore, be argued that where good-quality sausages are available, the general standard of diet will be raised, if only by a fractional degree. Thus there is some evidence for the thesis that poor quality foods—even of such incidental importance as sausages or jam—may, if sufficient of them appear on the market, in the long run exert a deleterious effect on health. Dieticians may dispute whether there is any 'harm' in the use of an innocuous yellow dye to give an attractive appearance to a cake whose price precludes the use of real eggs. Most people will probably endorse the simple view that chemical and other scientific methods which enable poor quality to masquerade as good quality are contrary to the interests of national health, even though the procedures used are not of themselves actively harmful.

The work of public analysts, reinforced by the press and public opinion, has done much to put down the grosser forms of adulteration. A comparatively high standard of health is enjoyed by modern Britain; and, in addition to aiming at the provision of 'honest' food, manufacturers now do many things purely in the cause of nutrition. Thus the flour miller has modified his process to include more vitamin B_1; the margarine manufacturer adds vitamins A and D; and the vegetable canner studies the effect of his process on vitamin C. But the food technologist's second, and more important, object—to improve the acceptability of the commodities he handles—has also an indirect bearing on nutrition. A clear but unexpected nutritional lesson of the 1939-45 war and the period that followed was that the commonest harmful effect of 'bad' feeding was due to simple underfeeding. This under-nutrition, while primarily arising from an insufficient supply of food, was also in part due to the refusal to eat unaccustomed or unattractive food. For example, people complained of an inadequate diet when meat supplies dwindled, even though bread was plentiful. In such circumstances, the manufacturer of jam, even of 'poor quality' jam, is performing a service to health if he enables bread to be eaten. And is not the man who dyes attractively the eggless cake also praiseworthy?

This ethical problem is raised sharply by the simulation of butter by margarine. In the United States, the interests of the farming community bulk large in the eyes of Congress and the Administration, which was persuaded that it was unethical for cheap margarine to be coloured in such a way that it could be mistaken for butter. In consequence, margarine had perforce to be sold looking like lard. It is only custom which causes us to prefer butter butter-coloured. But this custom is very strong; indeed, in many places it is so strong that butter itself is coloured artificially if its natural hue is not thought to be sufficiently yellow to please the consumer. And the strength of this prejudice is such that margarine, coloured white, is little liked in America, even though its manufacturers sell it with a pinch of dye included in the wrapping, just as a pinch of salt is wrapped up with the packet of potato crisps. What then is to be said of the British margarine manufacturer? He sells at a low price a wholesome article possessing a nutritional value almost identical with that of butter. Is he, then, not contributing to the national nutrition if the colouring artifices he adopts to make his product resemble butter succeed in persuading people to eat it—even though these manoeuvres were originally adopted to increase his sales and hence his profits?

As with so many problems of good and bad in this world, the just solution is probably a compromise. The manufacturer who produces a tolerably good article, but one which is of itself unattractive to the consumer, is not blameworthy if he tries his best to present his product in the most favourable light. The uneaten dried salted cod, of British wartime notoriety, would have benefited the nutrition of the nation if some ingenious technologist could have made it resemble Scotch salmon. But the cleverness of the manufacturer is bad if it is carried to such lengths that the purchaser may imagine that a poor article is in truth a good article of a different sort. We might compare the food technologist to a barrister who is expected to present his client in the most favourable light but who is not allowed to tell lies about him.

At this point it is appropriate to consider the subject of the colour of food, not only from the point of view of its effect on nutrition, as in the instance of margarine, but from a more general standpoint. The type of food we eat and the way we divide it into meals depend, to a very much larger degree than we think, on custom and not nutritional need. And a number of our ingrained food habits and traditions are concerned with colour. For example, the only eggs which can be successfully marketed in the city of Boston, Massachusetts, are brown eggs. On the other hand, only white eggs will be accepted by the dealers in the city of New York. Then there is a long and obscure history of colour prejudice about bread. Before the invention of the modern steel roller, the production of really white flour was an expensive process. This white flour was more delicate in texture and flavour than the coarser brown flour used by ordinary people, and consequently it was popular with the well-to-do. It therefore acquired a prestige additional to its dietetic quality, and this prestige attached itself to 'whiteness'. Thus, when new developments in milling technology made it possible to produce very white flour, flour of extreme whiteness was manufactured even though in some instances the flavour suffered. Furthermore, whiteness was achieved not only by removing all the darker particles of the grain but also by bleaching what remained. We thus have the paradox that, whereas yellowness is demanded in a naturally white substance such as margarine, in flour whiteness is required and all traces of yellow colour are removed by chemical means at some trouble, expense and damage to the food. So insistent is the popular demand for white flour that the Central Experimental Station at Winnipeg in Canada spent much time in attempting to breed a strain of wheat which should be free from the naturally occurring carotenoid pigments which are normally present in the grain and give a slightly creamy colour to flour.

Food traders must please their customers or go out of business. Even Government Departments dealing in food must ultimately bow to the likes, dislikes and customs of the public they serve. If a population is starving for want of rice, it continues to starve for some time if it is given wheat instead of the rice for which it is clamouring. At a lower level of need is the demand in Britain for chocolate Swiss roll. It has been observed that, when a housewife asks for chocolate Swiss roll, she wants something that looks like a Swiss roll and is chocolate-coloured. If chocolate is unobtainable, she is just as happy to receive a vanilla-flavoured Swiss roll coloured with a dye to look like chocolate. Is the manufacturer to be blamed for ministering thus to her harmless pleasure?

Another example of the powerful attraction of colour—again brownness—is provided by the dyeing of kippers. The traditional way to make kippers was to smoke herrings over oak chips. During this process the kippers became brown; but the real purpose of the process was to preserve the fish without the necessity for strongly salting them. In recent times, speedier transport and improved refrigeration have reduced the necessity for depending on lengthy smoking to preserve kippers. Cheaper and more convenient methods, which do not result in so much loss of weight, are, therefore, employed in kippering. But, because people are accustomed to brown kippers, the brownness is maintained, and often exaggerated, by dyeing—to the anger of those who enjoyed the taste of the traditionally manufactured product.

The artificial colouring of foods to improve their attractiveness is as defensible ethically as the artificial colouring of ladies' faces. In both instances the *necessity* for technical enhancement is to be deplored; but, if the necessity exists, an all-round increase in happiness is gained by the use of harmless deception. Certainly great pains are nowadays taken to ensure the harmlessness of food colours. This was not always so, but the lessons of the past have, in this respect at least, been well learned.

The primary activity of the food scientist, however, is to make possible the assembly of the enormous amounts needed by large modern cities. Just as the engineers who achieved the manufacture of iron pipes capable of keeping drinking water separate from sewage are the real but unhonoured heroes of modern public health, so the makers of railway trains, internal combustion engines, refrigerators and canning equipment are the men who have made possible the varied diet of modern Britain. Before we condemn this or that treatment of a foodstuff, we must always examine its purpose. Many of the manipulations for which the millers or the canners or the manufacturers of ice cream are blamed have good technical reasons to justify them.

There are four principal ways by which foods can be preserved long enough to enable them to be used to feed a city. The first is by taking advantage of a naturally stable stage in the production of the food. Unmilled grain is naturally stable and can be stored under suitable conditions for years. Live cattle, sheep, pigs and poultry are another example of food in its naturally stable state.

The second method is to maintain the stability of food, and thus keep it from going bad, by refrigeration. In order to explain the principles of refrigeration a few elementary technicalities are essential. A piece of meat, to take one example, goes bad if it is left too long on the kitchen table for two reasons: autolysis and infection.

Animal tissues, that is to say meat, are made up of a honeycomb of individual cells. When an animal is conceived, two cells fuse. This single fused cell then starts an independent life by budding into four and then into eight and so on in geometrical progression until a large multicellular mass is produced as big as an ox. The mass indeed is an ox. Nevertheless, each individual cell retains much of the complex biochemical machinery which enabled its original progenitor to live on its own.

When the ox dies its cells in a little while die too. Then the chemical enzymes, which in life were systematically engaged in the ordered existence of the cell and in handling the nutrients by which it was maintained, have only the structure of the cell itself within their reach and themselves cause its breakdown. This is autolysis.

But the enzymes, be it noted, are chemical regulators which bring about the chemical reactions of the cell and control their speed. At low temperatures the speed of reaction is reduced. Hence refrigeration delays autolysis although it does not completely stop it.

The second form of breakdown and decay of tissues after death (be they the tissues of animals or of vegetables) is due to the activity of bacteria. Here again, low temperature slows down or prevents the growth of these bacteria and hence retards the disintegration of the materials upon which they feed.

Refrigeration, in short, is a useful method of delaying the decay of food. It is very widely used and permits the storage of many perishable commodities; but it possesses one serious drawback. This disadvantage arises from the fact that the ice derived from a certain volume of water is larger than the water from which it is formed. Hence, if a food such as a cabbage, which is built up of a comparatively regular structure of rather rigid cells, is frozen, the expansion occurring when the watery content of the cells changes into ice ruptures the cellular structure. This rupture disorganises the enzyme systems of the cell which thereupon cause rapid degeneration of the cell components themselves.

Recently, methods have been devised for avoiding this form of autolysis. These methods have been used in modern quick-freezing processes. For many foods, there is nothing new in quick-freezing. A piece of beef quick-frozen is merely a piece of frozen beef. But quick-frozen green peas are something much better than peas frozen. The improvement depends on preventing autolysis.

This is due to the action of enzymes, and all enzymes are destroyed by heat. The secret, therefore, in the preparation of quick-frozen green peas is a preliminary scalding to destroy the enzymes. When this is done, the peas may be frozen with impunity. Their flavour is retained because the enzymes which would otherwise cause rapid deterioration as soon as the cells were burst open by freezing have been put out of action. Similarly, quick-frozen strawberries have been subjected to a preliminary scalding in sugar syrup before they are frozen.

The third main method of delaying the decay of food is drying. Bacteria are living creatures and as such require moisture in order to exist. Enzymes also only act when in watery solution. Almost the only type of deterioration which can occur in food from which moisture has been removed is chemical combination with atmospheric oxygen. Tallowy flavour in stored fat is due to this type of oxidation.

Preservation of food by drying is not new. Biltong and other varieties of dried meat and fish have been known since ancient times. Modern techniques, however, enable foods to be dried with less loss of flavour and quality. The main technical problem in drying a food such as, say, milk which does not possess a cellular structure is the removal of moisture without damaging the protein. When one boils an egg, the albumen or white, which is a protein substance, becomes 'denatured'. The practical effect of denaturation is to render the albumen insoluble. Similarly, strong heating of milk protein damages its solubility and thus prevents the reconstitution of the dried milk. When milk is dried by running it in a thin film over heated rollers and immediately scraping it off again, some of its protein becomes denatured. Roller-dried milk is, therefore, not completely soluble. To avoid this disadvantage, spray-drying can be adopted. In this process, the milk is squirted as a fine mist into the top of a drum through which hot air is passed in such a manner that the spray of milk falls to the bottom of the drum as a dry powder. Spray-drying is now used for many types of food other than milk.

But the type of food drying which has attracted most attention during recent years is that rather pompously called 'dehydration'. The scientific principle involved in 'dehydration' is basically that used in quick freezing—destruction of enzymes before the process of drying is begun. Anyone who has watched the darkening of colour in the cut surface of a raw potato has seen the rapidity with which enzymes act when the cellular structure of a vegetable is disrupted. If potatoes are dried without any preliminary treatment, they can only be used for animal feeding. After preliminary scalding and skilful drying, however, the resultant 'dehydrated' potato powder when reconstituted with hot water can hardly be distinguished from freshly cooked and mashed potatoes.

The fourth important method of preserving food is by canning. The principle behind this procedure is the destruction by heat of the bacteria which are all-pervasive in the atmosphere. It is the attack of these bacteria which is responsible for the normal processes of decay and putrefaction. When an animal or plant is alive it can protect itself against bacteria; when it dies the bacteria play their part as biological scavengers.

Nicholas Appert discovered the process of bottling, which is, of course, the same as that of canning, at the end of the eighteenth century. He was supplying bottled meats, vegetables, fruits and milk to the French navy in 1806—that is, long before Pasteur had elucidated the facts of bacterial infection. Although Donkin and Hall's factory in Bermondsey was successfully supplying the British navy with canned meat in 1813, and Gamble and Co. were also doing so in 1818, the canned foods supplied by a subsequent manufacturer in 1845 caused disaster to at least one naval expedition. Large amounts went bad owing to the use of containers which were too big to be sterilised in the apparatus available. It is dangerous not to understand the principle upon which a procedure is based. The prejudice arising from early failures in canning technique has persisted long beyond the extinction of the causes giving rise to it. Yet foods canned under modern conditions are less likely to be infected than those marketed fresh and their nutritional value is substantially the same.

Before we turn to examine the treatment given to separate foods under modern conditions, it is useful to remember again that a good healthy diet can be constructed from many combinations of food and that there is not necessarily any absolute merit in the precise kind of food we are accustomed to eat.

In 1650, Sir Thomas Browne wrote: 'While we single out several dishes and reject others, the selection seems but arbitrary, or upon opinion; for many are commended and cried upon in one age, which are decried and nauseated in another'. Nowadays, sour milk is unpleasant to a Briton but cream cheese is pleasant; decaying chicken is bad but decaying pheasant good. In the Western world the quality of an egg would be condemned which would receive praise in China. And there are even more subtle aspects to the assessment of quality. The same article may be approved or condemned by the same people in different environments. For example, during the 1939 war it was found that airmen would complain bitterly about the quality of sausages served to them in R.A.F. messes but would enjoy sausages bought in canteens outside their camp. The sausages were identical.

It seems, therefore, that there are two kinds of good quality. The first is that which satisfies the aesthetic feelings of the consumer—feelings which are variable in terms both of space and time. There is no 'absolute' in this good. The second kind of food quality, however, does possess real validity. It consists in the absence of harmful ingredients or treatments calculated to cause a deterioration in the natural nutritional value of the article. Much of what follows will deal with this second kind of quality, but the first sort must also be considered. We condemn a manufacturer who sells a food from which half the nourishment has been removed. What is the verdict if the food contains all its nutrients yet is so unappetising that no one will eat it?

2

Modern Bread

LESS bread is eaten in rich countries, where the standard of living is high, than in poor countries where it is low. In the United States about 3 lb. of flour is eaten per head of the population per week. This includes flour used in cakes, biscuits and cooked foods as well as in bread. In Great Britain in 1934, each week saw 3·7 lbs. of flour eaten per head; but in 1949, when the standard of diet had been depressed by war, flour consumption had risen to 4·2 lb. Flour is the cheapest source of energy and in almost all Western countries is the single biggest contributor of calories to the diet. Bread is not an actively popular food; when its consumption rises, it can be taken as axiomatic that the standard of living is falling.

People have strong emotional feelings about food. It is a commonplace that 'nobody can cook today as well as mother used to do'. Particularly violent sentiments are aroused by bread, due perhaps to its central position in religious liturgy. Few people, therefore, be they scientists or laymen, are able to discuss problems of bread composition temperately. The modern trend seems to be towards continuously milder, less distinctive flavour. In countries where wheat is the predominant cereal there has long been a preference for white bread rather than brown, because the latter has tended to be coarser and less digestible. Before 1880 white flour was obtained by sifting wheat which had been ground between stones. This white flour was by no means pure white; it did not keep particularly well, and contained a proportion of the husk, intermediate grain layers and embryo. Thus the bread it produced still possessed a distinctive flavour. A modern British white loaf, however, might be said to have a 'neutral' flavour. This is more popular than the flavour of bread made from wartime '85 per cent. extraction' flour. An American 1 lb. loaf, made from flour manufactured with all the advantages of modern technology, is as big as a 28 oz. loaf of British wartime bread and has as 'negative' a flavour as cotton wool.

Bakers, whose prosperity depends on selling their wares to their customers and who, therefore, could be expected to know, are convinced that the public demand a loaf which is very large for its weight. The bread must, of course, be regular in texture and, if possible, white in colour; but, above all, the loaf must be big. Bakers use a number of technical terms of approval to describe this 'quality' bread. It is called 'bold', 'well aerated', 'large volumed', 'well risen', 'well piled', or 'well built'. A tremendous amount of scientific effort and thought has been applied to this single problem of how to produce a large loaf. Wheat is specially imported and blended; elaborate and expensive instruments have been designed to test its powers to make big loaves; chemical 'improvers' have been invented to increase the size of the bread made from 'weak' wheat, and botanists and geneticists have patiently developed strains of wheat which should be 'stronger' than their progenitors. All this has been done in pursuit of size.

Most Canadian flour is 'strong'—*i.e.*, it makes a large, 'bold' loaf—whereas much of the wheat grown in the British Isles produces 'weak' flour. The factor that determines the 'strength' of flour is the presence of an increased percentage of gluten, which is the principal protein of wheat. Almost any normal British diet contains a sufficiency of protein. The presence of more protein in the 'strong' wheat which the modern baker so imperatively demands is, therefore, not based on any nutritional consideration, but is entirely on account of the superior technical qualities it possesses. A loaf made exclusively from English flour is 'heavy' in comparison with typical modern bread and has a somewhat rough texture. Bread from 'strong' flour, on the other hand, is lighter and has a 'silky' appearance. It is interesting to reflect that subtle differences in the quality of bread, many of them almost certainly too esoteric to attract the attention of the casual consumer, materially influence the import policy of the nation and the elaborate equipment of the great milling industry.

In order to appreciate the significance of several steps which have been taken—some for technical and aesthetic, and some for nutritional reasons—and have been the cause of much recent controversy, it is necessary briefly to outline the details of modern milling procedure.

Before wheat is milled, it is cleaned by machines, some of which are extremely ingenious. It is first passed over sieves which remove impurities, dirt and weed seeds which are larger or smaller than the wheat grains. Next, it is passed through 'indent' machines which take out small seeds and broken grains which are approximately the same size as the wheat but of different shapes. Small 'indents' remove weed seeds which are smaller than wheat, of which those from a plant called cockle are among the commonest, while bigger 'indents' lift out the wheat, leaving behind the larger grains of oats, barley and rye. Then the grain is scoured and brushed to loosen and remove further dirt and what is called 'bees'-wing'. Light grain, dust and chaff are aspirated by suction and more dirt and fungi, such as smut, are removed by washing.

For satisfactory milling, different varieties of wheat must be brought to different degrees of moisture. The blend of 'strong' and 'weak' wheat, suitably 'conditioned' to the desired moisture, then undergoes the milling process.

In milling, the wheat is not ground up and sifted as used to be done when mill-stones were used. It is subjected to a 'gradual reduction' process. Pairs of fluted steel rollers revolving at different speeds tear open the grain rather than crush it. The grain passes through four or five of these pairs; and after each 'treatment' it is divided into three fractions by means of sieves. A small amount of flour at this stage is sifted out through a silk screen, while the semolina, which is flour in little lumps, passes through a sieve over which the larger pieces of torn grain pass to the next set of rollers. After four or five 'breaks', the bran is almost entirely separated from the semolina. The semolina is then graded by means of more sieves, separated from broken particles of the outer wheat layers in machines called 'purifiers' and then powdered into flour by being passed between a series of pairs of smooth 'reduction' rollers. These rollers flatten any remaining pieces of bran or embryo, so that they can be removed by the silk screens through which the flour itself passes.

During this process of milling, a number of 'streams' of flour of varying degrees of purity are produced. The purest are known as 'patent' flour, and a mixture of all the flour streams is called 'straight run'. Brown flours contain the finer parts of the outer grain layers as well as the flour proper. Wholemeal flour is usually made up of 95 per cent. of the total grain, only the coarsest bran particles being removed.

Here arises the controversy whether brown bread is more nutritious than white. But before we consider this, some important facts in the chemistry of wheat are relevant. To begin with, the major part of the wheat grain is made up of stored starch granules which are to serve the plant as food until it has grown sufficiently to enable it to support itself from its own roots and leaves. These starch granules form almost the whole of the white flour. In the grain, separating the stored starch from the embryo plant, is a thin layer called the *scutellum*. This small structure has recently been discovered to be extremely rich in vitamin B_1. The embryo itself also contains vitamin B_1 but in lower concentration than the scutellum. It is, however, a somewhat fatty tissue, and its incorporation in flour has a damaging effect on keeping quality. Surrounding the grain, as an eggshell surrounds an egg, is a protective layer of tough bran, within which is an intermediate layer also containing some vitamin B_1 and part of the protein of the grain.

Up to 1940 the bread most commonly eaten in the United Kingdom was made from white flour with an 'extraction rate' of about 72 per cent. That is to say, 72 per cent. of the original wheat was extracted as flour. In 1942 the extraction rate was raised to 85 per cent. in order to utilise for human food a larger proportion of the wheat imported into the country. At the same time the protagonists of brown bread claimed that the 85 per cent. extraction flour conferred a nutritional benefit on the population. In 1945 the views of an official technical committee were published in a Government White Paper. This committee argued that flour of at least 80 per cent. extraction possessed so substantial a nutritional advantage over 72 per cent. extraction flour that anything failing to achieve this standard should be permanently prohibited by law.

Restriction of freedom is so abhorrent to a civilised community that, wherever it is imposed, no matter how trifling the occasion, it must be fully justified. Science is today so technical that many political acts based on scientific reasons must be taken on trust. But wherever the scientific facts are comprehensible to the educated layman, they ought to be put before him so that he may form his own opinion and not rely at second hand on the judgement of the scientist who, however expert in his own subject, has often been found to possess as little common sense as the next man.

Now the principal respects in which it is held 80 per cent.-extraction flour exceeds 72 per cent.-extraction flour in nutritional value are that it contains 0·26 milligrams of vitamin B_1, 1·20 milligrams of another vitamin, nicotinic acid, and 1·8 milligrams of iron per 100 grams compared with 0·11 milligrams of vitamin B_1, 0·72 milligrams of nicotinic acid and 1·0 milligrams of iron in 72 per cent.-extraction flour. On the other hand, higher extraction flour is generally considered to be less attractive in flavour and consistency; it is less suitable for making cakes and biscuits, does not keep so well, and contains more fibre and more of a substance called 'phytic acid' which will be discussed in further detail later.

What is the scientific evidence upon which it is so strongly believed that increased vitamin B_1, nicotinic acid and iron in bread will improve the national health in Britain? Acute deficiency of vitamin B_1 produces beri-beri. This disease, however, is quite unknown in the United Kingdom. Moderate deficiency of vitamin B_1, it is true, causes a number of non-specific symptoms, among which the most consistent is lack of appetite. Lack of appetite can, however, arise for many different reasons; and the clinical diagnosis of mild deficiency of vitamin B_1 is, therefore, very difficult to establish. It is fair to say that before 1940, when white bread was generally eaten in Britain, there was no significant number of diagnoses of vitamin B_1 deficiency even among the poorest classes of the population.

In 1945, a careful study was made at the University of Minnesota of the effect of deprivation of vitamin B_1 on human volunteers. All the classical symptoms of failure of appetite, apathy and mental depression and a number of more detailed physiological and biochemical stigmata were observed. These were prevented or, if previously induced by acute experimental deficiency, were corrected by a diet containing 0·23 milligrams of vitamin B_1 with each 1,000 calories absorbed. If a calculation is made of the vitamin B_1 content of the diet eaten in 1936 by the poorest group of the population studied by Lord Boyd Orr, it is interesting to observe that they were, in fact, obtaining 0·29 milligrams of vitamin B_1 per 1,000 calories.

It is perhaps an unduly rigid approach, in a subject so complex as social medicine, to expect to find, in a population such as that in pre-1939 Britain, on the one hand, specific symptoms of deficiency of a single vitamin and, on the other hand, a consumption of the vitamin demonstrably below a level known to produce damage to health. When we are working to achieve optimal health we must be prepared to accept circumstantial evidence ; and such evidence of deficiency of vitamin B_1 can be argued by comparing the consumption of the poorest section of the community—0·29 milligrams of vitamin B_1 per 1,000 calories—with the 'basic estimates of thiamine (vitamin B_1) requirement' of 0·4 milligrams of vitamin B_1 per 1,000 calories recently proposed by a committee on nutrition of the British Medical Association, or with the 0·5 milligrams 'recommended' by the Food and Nutrition Board of the U.S. National Research Council. The argument would run that, since it is unquestioned that the diet of poor people in Britain fell below these estimates of need, even though no evidence of ill-health can be adduced to demonstrate resulting harm, the diet of the whole population ought to be reinforced as a compulsory public-health measure.

Another line of reasoning has been to argue that since 0·23, 0·4 or 0·5 milligrams of vitamin B_1, depending on the authority cited, are required per 1,000 calories of diet, a food which does not contain this ratio of vitamin B_1 to calories is capable of harming health. Flour of 80 per cent. extraction contains 0·76 milligrams of vitamin B_1 per 1,000 calories compared with 0.34 milligrams per 1,000 calories in 72 per cent.-extraction flour. Patent flour of about 50 per cent. extraction contains 0·24 milligrams of vitamin B_1 per 1,000 calories, and of this amount some will be lost in baking. It can thus be argued that white flour is potentially harmful. This method of approach, however, leads to a confusion of thought. Beer and sugar, for example, which do not contain any vitamin B_1, could be still more strongly deprecated on that ground; and, if we pursue the matter beyond vitamin B_1, there hardly exists a single foodstuff that would reach the standard of contributing in proportion to its calories all the nutrients needed for a balanced diet.

The argument for increasing the consumption of nicotinic acid in the national diet by maintaining by law a high extraction-rate for flour is also based on circumstantial evidence; for it cannot be claimed that any specific signs of nicotinic acid deficiency were manifest in the pre-1939 population. Pellagra, the deficiency disease which yields to nicotinic acid, has always been unknown in Great Britain, except as a medical curiosity. Indeed, even where it is endemic, it is not the result of simple nicotinic acid deficiency but is almost always associated with the consumption of maize as well. The only maize the British eat is what they get in their breakfast 'cornflakes'.

Thus, so far as the two B-vitamins, vitamin B_1 and nicotinic acid, are concerned, it can be said that, although a compulsory change from 72 per-cent. extraction flour to, say, 80 per cent.-extraction flour would bring the diet of the poorest section of the British population nearer to what, in the opinion of certain technical committees, is an optimum composition, clear evidence can hardly be adduced to show that ill-health existed prior to 1939 as a direct result of shortage of these vitamins. This could not be said of some sections of the United States, or of Newfoundland and many parts of the East, where greater poverty and a diet of less variety existed, but it holds good for Great Britain.

When it is decided to increase the vitamin content of flour, it can be done in a number of ways. First, there may be a crude incorporation of more of the outer layers of the grain and more embryo—*i.e.*, a simple increase of the extraction rate. Alternatively, in Canada, a technique was devised of milling wheat drier. This 'Canda approved' flour achieved a higher vitamin B_1 content without the necessity for incorporating in it as much of the rough outer fractions. It was discovered by British scientists that this was due to the powdering of the vitamin-rich scutellum and its consequent incorporation with the flour stream. In America, where a powerful pharmaceutical industry manufactures and markets synthetic vitamins with that vigour for which the United States is famous, Federal Standards for 'enriched' flour and bread have been made compulsory; and 1·9 milligrams of synthetic vitamin B_1, 1·15 milligrams of another vitamin, riboflavin, 13·7 milligrams of nicotinic acid and 12 milligrams of iron must be added to each pound of white flour of 70 per cent. extraction which bears the title 'enriched'. Evidence has been produced to show that this 'enrichment' policy has caused a decrease in the number of patients with 'florid' beri-beri and 'florid' pellagra seen in certain American hospitals.

Supplementary to the question of white bread or brown and low or high extraction rate, is the merit or demerit of adding chalk, or some other form of calcium, to flour.

Whether or not it is agreed that the additional amounts of vitamin B_1 and nicotinic acid supplied by high extraction flour are of benefit to the health of the people of Great Britain, it seems clear that there are certain disadvantages attaching to the use of the outer grain layers. The fat and certain other substances in the grain embryo unquestionably affect keeping quality unfavourably. Whether bread made from 'national' flour looks unappetising is a matter of opinion. But the presence of phytic acid in high-extraction flour poses a number of nutritional problems.

Phytic acid is a chemical substance which possesses the property of combining with calcium and also with iron. Calcium is one of the principal substances of which bones and teeth are composed; and there is some general evidence to suggest that the poor state of the teeth of the British population

—one of the most striking and deplorable deficiencies in the national health—is at least partly due to an inadequate supply of calcium in the pre-1939 diet. There was also a widespread incidence of mild anaemia due to an insufficient consumption of iron particularly among women.

The effect of the increased amount of phytic acid in the high-extraction flour provided between 1942 and 1950 would have been to make these two deficiencies worse: by combining chemically with some of the calcium and iron in the rest of the diet, the phytic acid would render it 'unavailable'. To prevent this, the Government on the advice of the Medical Research Council ruled that 7 oz. of chalk should be added to each 280 lb. sack of flour.

Although the Medical Research Council had much laboratory evidence of the chemical behaviour of phytic acid, their evidence was by no means complete nor was it universally accepted. For example, it was pointed out that wheat itself and yeast contained an enzyme called phytase which, during the time the dough was rising, broke down phytic acid and rendered it harmless. It was also discovered by scientists in South Africa that people could become accustomed to a diet containing more phytic acid and less calcium, and that their bodies could then deal with the situation without any demonstrable damage to health. Against this it was shown that, simultaneously with the addition of chalk to the bread, there had been an improvement in the state of the teeth of British children. This evidence was, however, difficult to assess because increased money prosperity and improved welfare services of many kinds had also accompanied the dental improvement. Furthermore, it is known that calcium alone will not ensure sound teeth. Nevertheless, the Medical Research Council's view prevailed in official policy and the amount of chalk in the national flour was increased to 14 oz. per sack.

Some paradoxical happenings resulted from this piece of nutrition policy. More than one miller of ancient reputation was embarrassed by the presence of lorries labelled 'Portland cement' delivering chalk at his premises, and there was for a time a shortage of whiting for the making of ceilings due to the demands of the Ministry of Food on a raw material of the building industry. It must be said, however, that no good evidence has been produced to show that any harm results from the consumption of the added chalk, which is included in a purified form called 'craeta preparata', the specifications of which have long been laid down for medical purposes by the British Pharmacopoeia. Chalk, thus added to flour with entirely benevolent intentions, does no harm, except in so far as it adulterates the flour to the extent of 0·3 per cent., and there is evidence, even if of an indirect character, that it does nutritional good.

Another type of addition is made to flour, also for benevolent reasons. As we have seen, a 'strong' flour makes a large, 'bold' loaf. But much of the flour derived from wheats grown in different parts of the world is not sufficiently 'strong' to make the large loaves which the baker desires to bake. It would be at least partly true to say that 'weak' flour comes from 'soft' currency countries. It is certainly true that 'strong' wheat comes from the lands where the currency is 'hard'. Be that as it may, the miller has for many years done what he can to make the best of it by adding 'improvers' to flour not possessed of the 'strength' he would like it to have. These 'improvers' are all chemicals which exert a powerful effect when they are added in amounts of about ten parts per million of flour. One of the commonest early 'improvers' was bromate; but in the 1920's another substance, nitrogen trichloride, the trade name of which is 'agene', became very widely employed in both Great Britain and the United States.

In November, 1949, one of the leading British cereal chemists, in a lecture to the Royal Society of Arts in London, said: 'If the best bread possible is to be made from all the wheats in the world, some of which do not yield flour ideal for bread-making, then the use of chemical improvers would seem to be essential; but naturally these chemicals must themselves be without any danger to health'. The final clause of this sentence encloses the difficulty. In 1946, it had been discovered by Sir Edward Mellanby that, when dogs were fed on bread made from flour treated with 'agene', they developed hysteria. The same condition was called 'running fits' in America. It was soon shown that the 'agene' combined with part of the protein of flour and that the compound formed was highly toxic to dogs and to a number of other animals. Although it was never proved that the consumption of 'agene' had in fact given rise to toxic symptoms in human beings, the circumstantial evidence of its danger was a great deal stronger than, for example, the evidence for benefit from brown bread, so that, first in the United States and a little later in Great Britain, its use as an 'improver' is being abandoned. Today, chlorine dioxide is being introduced instead.

Bread is a perishable commodity, at least in so far as it becomes stale fairly quickly. Stale, dry bread retains its nutritional value and can serve as food for those who are sufficiently hungry to be willing to eat it, but under the ordinary circumstances of civilised life stale bread is considered uneatable. The baker can adopt two principles in providing his customers with fresh and acceptable bread. First, he can so arrange his working hours that freshly baked bread is ready just when it is needed for delivery to the people who are going to eat it. This is the principle that has been followed up till now. In order to have fresh bread ready in the morning when the housewife wants it, however, the baker must work through the night. The process of bread-making depends on fermentation by yeast in the dough. Modern yeast is very much more vigorous in its behaviour and quicker to ferment than it was in the past; but, even so, the process of bread-making is a biological one and cannot be accelerated beyond a certain point. There would be impatient queues if the baker awaited dawn before beginning to work.

Night work is not popular, and the baker who proposes to provide bread as fresh as possible is presented with a problem. A recent development may prove to be the solution of the difficulty. It has been found that, if dough is prepared in the afternoon and the process of yeast fermentation started, it can be checked by putting the half-risen bread into a refrigerator overnight. In the morning, the dough is warmed again, the fermentation comes to completion and the bread is baked.

This process of 'refrigerated' dough, if it is found generally successful, may turn out to be another example of inventiveness easing disagreeable manual work.

The second expedient available to the baker who wants to supply bread always fresh is to prevent staleness by some technical or chemical method. Staling is not a simple loss of moisture; if stale bread is moistened, it is still stale bread to the consumer. Well-baked bread made from dough which has been properly fermented keeps better than bread made from unsatisfactorily fermented doughs. Recently a number of chemicals, of which glyceryl stearates, sorbitol stearates and polyoxy-ethylene stearates are three groups, have been used, more particularly in the United States, and have been found to delay the staling of bread. There is some doubt, however, as to whether these substances are entirely harmless.

One has no right to assume, *without question*, that a freshly baked loaf is better than one in which the freshness has been maintained by artificial means. But when the questions are asked they are not easy to answer without bias. Early in 1950 a scientific report was published of the steps taken to prevent the staling of bread issued to the British armed forces. In brief, the method adopted in the 1939–45 war had been to add a mixture of mineral paraffin and beeswax. The scientific report frankly reviewed the known dangers to health inherent in the persistent consumption of paraffin. It can also be doubted whether the daily ingestion of beeswax is to be recommended.

Flour is used to make a variety of commodities other than bread. In the systemisation which inevitably accompanied the Government's planned distribution of restricted supplies, the Ministry of Food of 1944 recognised five classes of manufactured foods containing flour. The first was bread, the second biscuits, the third materials such as sausage rolls containing meat or fish, the fourth, oddly enough, Christmas puddings and uncooked pudding mixtures, and the fifth, flour confectionery. This last group ranges from buns and scones, which contain, say, 9 per cent. of sugar and as much fat and about 2½ per cent. of eggs, all the way to rich cakes which are made up of equal parts of flour, fat, sugar and eggs.

Eggs are important in flour confectionery partly because of their nutritional value and flavour and partly on account of the technical properties of the albumen they contain. In times of shortage much scientific effort has been expended to devise a substitute for eggs which shall possess not necessarily their nutritional or aesthetic character but the same technical quality of holding a cake together or puffing up into a meringue. Two principal solutions have been found to this problem. Artificial 'egg' albumen can be made from fish. This was an invention of the Germans, who called it Weiking Eiweiss. Alternatively, an egg substitute can be made from slaughter-house blood. We have here another example of a legitimate use of scientific knowledge. This knowledge is that proteins from different sources possess similar properties, in this instance the properties of binding cakes. The fish albumen and the blood albumen are in almost every way equivalent to egg albumen. Where the substitution is incomplete, however, is when they are compared with whole egg which, by virtue of fat, vitamin A, vitamin D and iron from the yolk, is nutritionally superior.

There is a scientific reason for the existence of cake, quite apart from its popular attractions. Cake occupies in the world of cereal foods the same position as that held by kippers in the realm of fish. Its useful life is sufficiently long to enable it to be manufactured and distributed and then to be used over a period of days or sometimes weeks by the consumer. The length of time a cake will keep is proportional to the ratio between the amount of sugar and other soluble solids in it and the amount of water. Buns and scones, which are at the bottom of the cakes' social scale, soon grow mould and become stale if they are kept. A rich Dundee cake, however, full of sugar and of dried fruit which itself contains sugar, will remain in an edible state for a period of months.

We have already discussed some of the results arising from the pursuit of size in a loaf. Let us now discuss two aspects of the striving to attain 'purity'. The most remarkable recent example is the introduction of the so-called 'filth test' by the United States of America Food and Drug Administration.

A mouse's dropping is made up of a mass of faecal matter compounded round about fifty hairs from the animal's fur. These droppings may sometimes be so similar in size and shape to grains of wheat that the miller's cleaning machinery is unable to remove them. When this happens, they become disintegrated by the 'reduction' rolls. In 1945 the Association of Official Agricultural Chemists in the United States devoted a great deal of attention in their manual of analytical methods to the laboratory techniques which could be used for counting the number of mouse hairs in a pound of flour. There is now in existence a document entitled *Food and Drug Administration of the Federal Security Agency Circular No. 1* which describes how this can be done. Flour is boiled with dilute acid, digested with an enzyme called pancreatin and the flour mixture shaken with petrol. The mouse hairs collect at the intermediate water-petrol layer and can be counted by a suitable microscopic method.

It is clearly undesirable to have mouse droppings in flour, and every effort of reasonable good housekeeping must be taken to keep them out. But the problem is far from simple. Mice gain access to wheat as soon as it is harvested. Flour from reasonably clean new-crop wheat has been found to contain up to eighteen mouse hairs per lb., while flour from what would previously have been considered to be good quality old-crop wheat has been discovered to contain 50 to 180 hairs per lb. It would be dangerous to assert that a few mouse droppings in a pound of flour do no one any harm although it would be difficult to prove that they do. On aesthetic consideration alone their presence is to be condemned. But in this imperfect world it is difficult to attain perfection.

International harmony and economic stability alike, it seems, may hang on a mouse's hair. Part of Britain's export drive for dollars was made up of biscuits. When these were examined by the newly devised method of the United States of America Food and Drugs Administration for detecting 'extraneous material' (which is the polite name for the 'filth test') mouse hairs were discovered and the consignments refused. Successful freedom from 'extraneous materials' was finally achieved by the use of specially imported white flour from combine-harvested wheat from which guaranteed mouse-free biscuits could be made and exported. The normal flour was eaten at home.

In spite of abuses of this kind due to demands for excessively high standards, the introduction of the 'filth test' has done a great deal of good by showing the presence of contamination from mice, rats and insects, not only in flour but also in oatmeal, breakfast foods, spices and many other food ingredients and thus pointing to the need for greater care and cleanliness in handling.

A second curious example of the results of the modern trend towards 'purity' is that of wrapped bread. In the Britain of 1950 many more instances of food poisoning due to bacterial contamination occurred than in 1920. By far the commonest cause of this food poisoning was a food handler afflicted with intestinal salmonella infection who neglected to wash his or her hands after going to the lavatory. It had been shown repeatedly, by the Central Public Health Laboratory and at other centres, that when a person's hand was merely placed in contact with one side of a sheet of paper, the other side of which was resting on a piece of faecal material, bacterial organisms from the faeces could be cultured from the skin of the hand. With the knowledge of this fact and its important practical significance in mind, the Ministry of Health had attempted to publish a newspaper advertisement exhorting people to wash their hands after visiting the lavatory. The newspapers, however, although they were prepared to hint at all manner of human activities more sinful than defaecation, could not bring themselves to mention lavatories outright; they refused to accept the Ministry's advertisement. The best that could be done was to refer obliquely to 'personal hygiene'.

The prudishness inherent in this incident may perhaps be a part of the general, modern, Anglo-Saxon trend of thought towards what might be described as 'suburban standardisation'. This applies to food as well as to other aspects of life. At the same time as the number of cases of food infection was increasing, the taste for 'blue' cheeses fermented, like wines, with local micro-organisms was diminishing; home-made bread produced from local wheat was becoming obsolete; fewer people ate whitebait, a dish in which the fishes' intestines, backbones, tails and all are consumed; and pre-packed, nationally standardised foods, which in order to please the multitude cannot afford to cater for the taste of the individualist, have become increasingly common. And because food packed in this way is so frequently seen, it comes to be assumed that commodities ought not to be marketed in any other way. Yet, in spite of the pleasing appearance of a loaf in an individual wrapper and all the anecdotes, mostly unfounded, of the baker's boy dropping the bread on the road and wiping it on his coat before delivering it, there is no substantiated evidence to show that unwrapped bread is ever the cause of infection.

Nobody can prophecy the trend of social development. Each generation believes itself to be wiser than the one before it and each imagines that it will be able to guide events by the exercise of logical thought. Thus, in food technology we find, as has been exemplified in this discussion of flour products, a confident belief that new developments are advances on previous practice. This is sometimes, but perhaps not always so. Modern milling machinery enables large amounts of good quality and uniform flour to be produced. The pursuit of uniformity, however, and particularly of large size in the loaf, has led to the complex problems of 'improvers'. Again, the detailed study of the nutritional value of bread brings to light the difficulty of establishing a nutritional standard for this single item in view of the many social factors influencing the adequacy of the total diet of the population as a whole. And finally, the legitimate and desirable effort to improve the cleanliness and purity of flour products may lead to waste of irreplaceable food, part of which might safely be consumed.

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Meat

In Britain meat is traditionally a family dish purchased in the primary form of a joint. The music-hall song of the early twentieth century describes the roast beef of old England as being consumed 'hot on Sunday; cold on Monday; Tuesday, Wednesday, Thursday too, we eat it up as Irish stew'. When, therefore, the social forces of the time caused the family to diminish in size, scientific forces were brought to bear on the ox and the sheep so that their limbs and the more confused anatomical combinations making up recognised 'joints' became smaller also. This extraordinary achievement was attained in the following way.

It was observed that different parts of the animal body grow at different speeds and in a different chronological order. For example, the lamb when it is born is all head, shins and shanks, parts of low meat-value; as it develops, the body first lengthens and then thickens, so that the proportions of the head and shanks become less. There are two waves of growth; the primary one starts at the head, which is already advanced in growth at birth, and moves backwards, while the secondary one starts at the feet and tail. These waves of growth eventually meet at the loin, where the most valuable meat is situated. Similarly, growth gradients exist between the different tissues of the body: bone is early maturing, as could be deduced from the advanced state of the head and legs, muscle develops next, while fat is last to be formed.

These growth changes mean that the butcher could get 53 lb. of carcase for each 100 lb. of animal of the proportions of a newborn lamb, whereas he could get 67 lb. from each 100 lb. of full grown ram. The consumer would find 31 per cent. of edible meat and 17 per cent. of bone in the lamb compared with 62 per cent. of edible meat and only 4 per cent. of bone in the mature animal. Of the meat of the lamb, only 2 per cent. is recognisable fat, but there is 30 per cent. of fat in meat from the ram.

The importance of this knowledge is that the composition of a meat animal can be controlled to a very large degree by the way the animal is fed. When food is comparatively scarce the growth of the early maturing and dietetically unimportant head, legs and tail exerts an absolute priority on the available nutrients; the more valuable structures, such as the loin, together with the more valuable components, such as fat, have to go short. If, however, the animal is richly fed in the early stages of its development, the age changes are speeded up and a young animal can be produced with the desirable proportions and dietetic attributes of an older one. This procedure is useful in two practical ways. First, smaller animals with, in consequence, smaller 'joints' but containing the right proportion of meat and fat can be produced. Secondly, 'improved' breeds which are capable of being affected to a maximum degree by this procedure can be selected. For example, the growth of an 'unimproved' animal such as a wild boar is not much influenced by the plane of nutrition, whereas the best modern meat animals are highly susceptible.

Although it has nothing to do with our topic of food, it is interesting to consider the implications of these facts on human paediatrics. A low plane of nutrition in early life will produce a sheep with bones fully grown but with meagre muscular development and little fat. If this animal is put on a high nutritional plane later in life it will always tend to retain a somewhat 'angular' structure. On the other hand the beast fed on a high nutritional plane in its early days will tend to have a more rounded configuration, even if its nutritional plane is later reduced. Similarly, the current preoccupation with the nutrition of children and young people greatly accelerates their *rate* of growth in early life and will consequently tend, in the words of the agricultural scientist, to allow 'the more valuable loin to grow to its full genetic limit'. It is also interesting to notice that it has been found that if the rate of growth of young rats is slowed down by restricting their diet, the animals live significantly longer. This is in agreement with an observation of Edmonds* who, writing in London in 1832, pointed out the statistical justification for concluding that alternate periods of ample feeding followed by periods of hardship are the best insurance for human longevity.

The quality of meat depends on a number of factors, the most important of which is the relative proportion of muscle, fatty tissue and tendon. The composition of the meat is not the same in all parts of the same carcase. For example, in the same mutton carcase there may be 36 per cent. of fatty tissue in the loin and 22 per cent. in the leg.

Fat is highly important in meat. An optimum amount is desired; there can be too much as well as too little; and because certain parts of the carcase tend to put on fat at a quicker rate than others, one part may be over-fat, while fat in another may be in the correct proportion. For example, the loin of South American lamb fetches a higher price than the leg because the former has the right amount of fat, the latter too little. On the other hand, in mutton from South America, the leg brings a higher price than the loin because the loin has become too fat.

The factors affecting what people consider to be 'quality' in meat are worth studying a little further.

Fat is important when it is laid down under the skin, that is, subcutaneous fat, because it prevents the meat drying up both in storage and during cooking. This type of fat tends to thin out towards the ends of the extremities, and it is partly for this reason that breeders select beasts with short legs as meat producers. By doing this they reduce the difference in the degree of fattening between the leg and the loin. Fat deposited during the later stages of feeding is most important of all, especially in beef, because it then appears in the muscles themselves, as marbling fat, where it tends to break up the muscle bundles and make the meat tender. Thus it can be said that fat *in the right place* is valuable, not for itself but because it improves that nebulous property 'quality' in meat. In the wrong place, for example, round the kidneys, it is of little value and is sold as suet.

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*Edmonds T. R. 1832. "Life tables founded upon the discovery of a numerical law regulating the existence of every human being illustrated by a new theory of the cause producing health and longevity." London : J. Duncan.

Colour in meat influences judgement of quality in a more logical way than it does in many other foodstuffs. An orange pigment present in grass tends to be taken up gradually by beef animals in their fat. During periods of poor feeding fat is withdrawn from the animal's body but the pigment remains. Thus cows and old animals usually have darker coloured fat than young animals which have been quickly fattened. For this reason the butcher rightly considers beef with dark coloured fat to be of lower quality than that with fat of a paler colour. Apart from fat, the colour of muscle is also an index of quality. Muscles whose function it is to sustain prolonged action are darker in colour and more highly flavoured than those which are less used. Today, therefore, in an age when pronounced flavour is unpopular, paler coloured muscle is an index of 'quality'. The muscles of a horse are relatively dark in colour, as are also those of an old animal. Game animals—hare, grouse, deer—have muscles which are darker in colour and stronger in flavour than those of the domesticated rabbit, fowl and sheep.

The example of meat shows very clearly the two different premises upon which quality can be assessed in food. On the one hand there is quality in the sense of a mild flavour whose acceptability is dependent on the fashion and locality of the people judging it. The right amount of fat is also to a large degree a matter of fashion. Tenderness is a quality in meat for which there is perhaps a more fundamental justification. The texture of muscle, and so its eating qualities, depends on the grain or size of the 'bundles' within the muscle. In large animals, such as cattle, these bundles, and hence the grain and texture of the meat, are coarser than in small animals such as sheep. Since the size of the muscle fibres increases with age, the meat of the older animals tends to be coarser and tougher than that of younger bests. Coarseness of texture of meat can be affected by anything which tends to split up the 'bundles' of muscle fibres, *e.g.*, hanging, which causes the connective tissue to soften; beating with a chopper against the grain; or the deposition of marbling fat within the muscle. The agricultural and food scientists and the technical people, farmers, feeders, buyers, butchers are all expert in judging quality in this sense.

On the other hand the nutritional scientists and dieteticians apply a completely different set of criteria in judging meat as food. A famous textbook of dietetics points out that marbling fat in meat, the sign of the stock-feeder's highest success, is many times more expensive as a source of fat and hence of calories, than suet which may be derived from the same animal. The liberal economists of the nineteenth century who argued that the price of an article on the open market was indeed an index of its value are despised today; but the ordinary eater may feel that there is something to be said for a nicely marbled slice of beef.

The nutritional significance of meat is a subject in which this ordinary eater has traditionally been in conflict with the medical scientist. Two leading scientific workers have believed that there is evidence to show that a diet containing plenty of meat is conducive to health. In 1909, the first, Crichton-Brown, in a book called *Delusions in Diet*, wrote: 'The success of the races, their vitality and energy, might almost be measured by the degree in which animal flesh has entered into their diet'. An interesting sidelight on this statement is that it was written five years after an elaborate American study had been published which showed that restriction in protein, which is the principal nutrient in meat, far from damaging health, increased the vigour of a number of men who were doing heavy work under close scientific observation.

Meat is of nutritional importance in other respects than as a contributor of protein to the diet. First, although it has never been proved scientifically to be essential for the most efficient performance of physical work, it forms the nucleus of what the British working man at least considers to be a meal. Secondly, a number of chemical substances in meat, called 'extractives' by the German chemist Liebig, are known to stimulate appetite. Thus meat, quite apart from its own nutritional value, encourages an adequate consumption of other foods. Next, meat has recently been found to contain a number of vitamins, among which are those called the 'animal protein factor'. These are closely related to vitamin B_{12}, which not only plays a key role in the prevention of pernicious anaemia but is also known to stimulate growth in children and in many kinds of livestock. Meat is also a good source of dietary iron.

In the light of all this new information Dr. Cuthbertson, now Director of the Rowett Research Institute in Aberdeen, expressed himself in the following words: 'Statistically there is a high correlation between efficiency in its widest sense and a rich protein diet, and a low intake of animal protein is seldom coupled with high efficiency'. This opinion, however, can only be taken as giving qualified scientific support to meat as food since 'intake of animal protein' could mean milk-drinking just as much as meat-eating.

The nutritionists, as has been seen, approve of a substantial consumption of animal protein, and principally for that reason support the addition of meat to the diet; but up till the present their support has not been enthusiastic. They merely bracket meat with milk, cheese, and fish. But whereas these nutritional scientists recommend the enlightened housewife to buy the cheapest cuts of meat and thus obtain most grams of animal protein per penny, other scientists have been investigating the chemistry of good quality (in the ordinary sense) and the technique of transport and storage and thus, by implication encourage the housewife to buy good cuts of meat.

Unless meat contains a certain amount of lactic acid it is sticky and flabby in consistency and is liable to decompose very rapidly. This apparently subtle and obscure matter is in fact of fundamental interest. Muscular tissue, which is elastic in structure, acting in conjunction with the hinged framework of the bones, is the mechanical engine which enables animal movement to occur. Movement, which is axiomatically accompanied by the performance of work, can only be achieved through the combustion of some kind of fuel. The fuel for muscles is stored within their tissues in the form of a substance, glycogen, which is also called 'animal starch'. When the muscles are used glycogen is quite quickly 'burned'. It is when all the stored glycogen has been expended that a muscle becomes exhausted. When it is rested a physiological process is set in motion which restores the glycogen stocks.

The normal stock of glycogen in the muscles of, say, a cat is comparatively small. In a dog, which can run for a long time without tiring, larger stocks are found. Similarly the muscles of sheep possess more glycogen than those of pigs, and the great muscles of a horse, which are capable of doing hard work for prolonged periods, are richest of all. Another animal, the tissues of which are rich in glycogen, is the oyster, since its entire and single-minded effort is devoted to exerting a powerful muscular tension to keep its shell closed.

After the death of an animal the glycogen in its muscles breaks down to lactic acid. The important observation was made at Cambridge University that if animals were made tired just before they were killed, the amount of stored glycogen in their muscles was insufficient to produce enough lactic acid and in consequence the quality of the meat suffered and its keeping properties deteriorated. Animals may become exhausted in two principal ways—by fright and struggling at the slaughter-house or by being driven on foot immediately before being killed.

On this occasion, therefore, science and humane behaviour join to produce better quality meat. Where livestock and, particularly, pigs are concerned, death can with advantage be met with a calm mind and it is to everybody's benefit for 'the condemned animal to eat a hearty breakfast' and to be transported to execution in comfort. Thus the first factor in the satisfactory transport of meat comes into play while the animals are still alive and on their way from pasture or byre to the market and slaughter-house.

The second factor is the provision of reasonably satisfactory transport for carcasses from the slaughter-house to the butcher's shops or to the storage depot. We have already touched on some of the changes which occur in meat when it is kept. Some of these are beneficial to its quality as food. Partial breakdown of the muscle bundles makes meat tender.

Partial autolysis of protein improves flavour although a degree of change which would be welcomed in game would be deprecated in beef, mutton and pork as verging on putrefaction. An adequate concentration of lactic acid, as has already been pointed out, is essential during this stage of storage.

Meat is a moist foodstuff and as such is susceptible to infection by bacteria and moulds. The best way of minimising such infection is to ensure clean conditions of transport and storage. Before 1939 progress was being made in improving the sanitary condition of vehicles used for the transport of meat. During the war years all kinds of vans, lorries and carts were pressed into service. Sometimes vehicles which had been used for other commodities were used for meat without being adequately cleaned. Under such circumstances it is no matter for surprise if the meat did not keep satisfactorily.

The most commonly used method of preserving meat is the employment of low temperature. This is applied in two ways. The most direct method is freezing. If the temperature is reduced well below 32° F., almost all bacterial and autolytic changes are thereby brought to a standstill; but there are two disadvantages in freezing meat. First, if the freezing and thawing are not done in a standardised manner, the disruption of the cells is so severe that 'freezer burn' takes place and part of the meat becomes unfit for use. Secondly, the freezing, by its inevitable rupture of cellular structure, causes a deterioration in quality. Deterioration also arises from a chemical change which affects the fat. This change is somewhat similar to the 'drying' of the linseed oil used in paint.

In order to minimise the disruptive changes and consequent loss of flavour and quality due to freezing the process of 'chilling' was devised. In this procedure the meat is cooled but its temperature is not reduced as low as freezing-point. By this means normal deterioration is slowed up, although it is not completely halted. Thus, whereas frozen meat may be kept for several months, chilled meat can only be kept for the few weeks needed for its transport from, say, New Zealand to Great Britain. The chilling process requires considerable technical skill; otherwise losses in the form of 'drip' may become of serious magnitude. Unfortunately chilling, although less damaging to the quality than freezing, is not without its effect on the flavour of meat.

The scientific technique of freezing obviously enabled more meat to be provided on the British market, even though this meat was not of the highest gastronomic quality. Further technical study then developed chilling as a method equally capable of providing imported meat but less damaging to its quality. Much of the research resulting in the elaboration of these procedures was financed by the Government. Yet it was the Government's rationing technique which to some degree put back the clock and laid emphasis on meat as meat and not on fine quality meat.

As we have said, it was shown in 1940 by Professor McCance and his colleagues at Cambridge that a nutritionally adequate diet could be constructed for a population at war without meat at all. The practical value of meat to war-time planners was, therefore, as a basis for traditional meals and as an attractive ornament to civilised life. The rationing system was thus designed in the main to give an equal amount to every adult citizen, although to certain groups whose economic or strategic usefulness was above the average a bonus incentive of meat was given. For example, 'Category A' canteens received four times as much meat per head as was given to ordinary citizens who bought their meals in tea shops, and later in the war-time years coal-miners were given supplementary meat rations at home. But from 1940 onwards the quality of meat was hardly considered at all. Petrol was 'pool' petrol; cheese was 'ration' cheese; and meat was meat. Moreover, a further factor militating against quality was the smallness of the ration, which made it impossible for a family to obtain a recognisable joint. And the cooking in canteens, which did obtain complete joints, only contributed further to loss of quality.

Meat is at its best when carved from a newly roasted joint. But skill is required in carving, and the operation calls for a certain amount of trouble. A canteen aims to feed the maximum number of individuals in the minimum possible time. To do this it is convenient to carve the meat with a mechanical slicer.

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If freshly roasted hot meat is put on to such a machine, part of it may break up and large, even slices will not be obtained. The practice is therefore followed of cooking the joint on one day, allowing it to get cold, slicing it on a machine the following day and serving the cold meat on a hot plate with hot gravy. By this procedure it is possible to serve equal portions, but all of an equally uninteresting flavour and mediocre quality. Ten years of this practice are believed by caterers to have obliterated all knowledge on the part of canteen customers that there is anything better. History has indeed progressed a long way since the time when Dickens's footmen considered themselves unforgivably affronted if they were given cold meat.

Two technical developments in the provision of meat in Great Britain in the 1940's are interesting because they were revivals in modern dress of earlier practice. The first is 'dehydrated' meat. Dried meat as biltong is of great antiquity. The modern form of drying is carried out by cooking the meat, mincing it and then passing it over a steam-heated roller dryer. This process produces an article which is of use to troops and such people as yachtsmen who are unable to obtain fresh meat. When reconstituted with hot water it is indistinguishable from unprocessed meat minced and cooked.

'Dehydration', indeed, has much to its credit. Dried milk is the basis of almost all artificial infant foods, and dried egg is nearly as good as fresh egg when used as an ingredient of cakes. 'Dehydrated' meat retains the nutritional value of fresh meat, is light in weight, and can be compressed into blocks useful under many special circumstances. Unfortunately, however, it cannot reproduce the special attributes of fresh meat of good quality. Its most important property is its durability. Since we now live in continual expectation of new wars, this quality is of considerable strategic significance.

A second technical development is the return of whale meat as a civilised food. During recent years large numbers of whales have been slaughtered annually and the only parts of their bodies to be saved have been the fat, used as a basis for margarine, and a small proportion of their bone. It has been customary to throw all the meat back into the sea. Up till the nineteenth century, however, the inhabitants of the Scottish Hebrides used to launch their boats whenever a school of whales was sighted off their coasts and attempt to drive the beasts on shore. Should they succeed in doing this, their happiness was unbounded at having acquired a season's supply of meat.

In 1950, when by chance several large schools became stranded on the shores of the islands and mainland of Scotland, the local authorities did everything they could to get rid of them. Fishermen were hired to tow them back to sea, pig farmers were begged to accept them, and eventually in one place a tug was hired at some expense to take the bodies away. But a few years before this event, the Low Temperature Research Station at Cambridge had interested the Ministry of Food in a scheme for using whale meat as human food. The first samples of meat put on to the market were unpopular: at first taste the meat resembled beef, but after a few moment's mastication a pronounced flavour of cod-liver oil became evident. Investigation soon showed that the method of slaughtering the whales was not up to a reasonable standard as recognised by competent land-butchers.

When whales are killed for their fat, the 'catching' vessel fires an explosive shell attached to a harpoon into the animal. As soon as the whale is dead, its body is blown up with compressed air to make it float and a flag is stuck into it. The 'catching' ship then goes off to look for other game. In due course, all the dead whales are towed to a factory ship where they are dealt with one by one. It thus follows that, though some of the animals may be cut up soon after they are killed, most of the carcasses are left floating about for a considerable time; and some of them, through accident or oversight, or through being used as fenders to prevent the 'catching' boats bumping against the factory ship, may be in an advanced state of decay before being cleaned and dissected. Under these whaling methods, which, it must be remembered, were designed principally for the collection of fat, it was not surprising that the meat was of a pronounced flavour. So, when these facts were realised, competent veterinarians were sent with the whaling ships, and the catching was so organised that the meat was cut up as soon after the animals were killed as possible. Through the application of common-sense principles of this sort, the quality of the whale-meat marketed was much improved.

Whale-meat has a composition almost identical with that of lean beef; and it could, therefore, serve as the nutritional equivalent of meat from the normal terrestial domestic animals. We can in consequence expect to find it on the market when war or financial stringency renders the usual forms of meat scarce. Unfortunately, unless it is very skilfully cooked and of the highest quality, it is impossible to avoid some trace of a characteristic fishy flavour. Competent manufacturers have found that they can include a proportion of whale-meat in meat-loaf or sausages without affecting the normal flavour. This offers a feasible method for utilising it painlessly.

We have already mentioned refrigeration and drying as methods of dealing with the inherently unstable nature of meat. The picture must be rounded off by reviewing some aspects of two further types of preservation—canning and what might be called quasi-chemical methods.

In Britain the most important type of canned meat is corned beef. Indeed, so familiar did corned beef become in the war years that it has since been considered interchangeable with butcher's meat as a rationed commodity. Although corned beef is a valuable foodstuff it is not, in fact, equivalent to fresh beef either on the basis of dietetic quality or nutritional value. Corned beef is manufactured by powerfully compressing meat and then sterilising it at high temperature in the cans into which it is packed. During the compression, juice is expressed, and forms, when evaporated, one of the branded meat extracts. For many years it was believed that these meat extracts were devoid of nutritional value. It has, however, been found that they contain high concentrations of the two B-vitamins, riboflavin and nicotinic acid. But what is won on the roundabouts is lost on the swings. Corned beef, from which the nutrients in meat extract have been removed, contains in consequence less riboflavin and nicotinic acid than fresh meat.

This is a matter of consequence when, as at the seige of Tobruk, corned beef forms a major component of a restricted diet.

The chemical preservatives used to prevent the deterioration of meat are few. The commonest is salt; but the expansion in refrigeration, together with the modern aversion to strong flavour, has led to a great diminution in consumption of salt meat. Almost the only remaining important meat product that depends on chemical preservation is bacon. The long-standing and traditional reputation of this form of meat has left the use of sodium nitrite, in which it is pickled, entirely uncriticised, although almost all other of the older preservatives have today been dropped.

There are certain newer chemical preservatives coming into use, particularly in America, where the addiction to pre-packing tends to make their employment more urgently necessary. Although no harm has been attributed to, say, nor-dihydroguairietic acid—used to prevent rancidity in the fat of pre-packed chicken—one could wish that the hazard, no matter how remote, of its employment had not been incurred.

More significant than any hazard due to the possible introduction of new chemical substances into the treatment of meat is the possibility of infection. Casual infection due to the proliferation of bacteria derived from the handling of meat already dead is not usually harmful to the health of people eating the meat. Poor hygiene in the slaughter-house or in transport and storage merely shortens the life of the meat as acceptable food. It has been mathematically proved that the life of chilled beef is inversely proportional to the logarithm of the number of bacteria per unit of surface. In this connection, however, it is interesting to observe that, the nearer the temperature of the chill-room or cold-store is to the soil temperature, the greater will be the number of contaminating organisms capable of growing on chilled meat. For this reason chilled beef from the tropics may have a longer storage life than chilled beef from more temperate countries.

The danger of eating the meat of diseased animals has been recognised since biblical times. The Mosaic law was drawn up in great detail on the subject of permitted and prohibited meat. Nowadays, it is obligatory almost everywhere for all animals killed for meat to be examined by a meat inspector appointed by a veterinary surgeon or by the local Medical Officer of Health. This provision applies to Scotland along with most other civilised countries, but it does not apply to England. The English merely insist that all *imported* meat should be accompanied by a veterinary death certificate.

Veterinary examination of animals at a collecting centre or slaughter-house serves two distinct purposes. It can detect diseases which would be harmful to human beings eating the affected animals, and it can also discover diseases harmful to other animals. Among the most important of the latter is foot-and-mouth disease because of its great infectiousness.

The disease of animals considered to present the greatest hazard to man is bovine tuberculosis. By vigorous action, regular tuberculin tests and ruthless slaughter of infected animals, the United States of America has succeeded in almost completely eradicating this disease from her cattle within a period of about 25 years. In Britain, the best that can be said is that, in 1949, approximately 33 per cent. of the cattle in Scotland were known *not* to be affected by tuberculosis; 25 per cent. of the cattle in Wales were tubercle-free; in England the figure was 10 per cent. Tuberculosis is the principal reason why beef and pig carcasses are condemned as unfit for human consumption. Sheep, on the other hand, are virtually immune, partly, it is believed, because they are naturally resistant, and partly because their outdoor life is good for them.

It is, of course, difficult to assess the amount of human tuberculosis arising from the consumption of infected meat slipping through the hands of the inspectors. The estimate usually accepted for the annual number of deaths in Great Britain due to bovine tuberculosis derived from milk and meat is 2,000. But besides the human hazard, not only of death but of infection, there is a heavy loss of food and wealth. During 1945, for example, over 30,000 beef carcasses alone were entirely condemned and destroyed and many more were partly wasted because of localised infection. Pigs, too, are susceptible to bovine tuberculosis and also, unfortunately for them, to avian tuberculosis as well, that is the form of the disease transmitted by birds. However, since they are usually slaughtered at the youthful age of six to eight months old, the disease seldom has the opportunity of establishing itself fully, and most parts of infected animals can often be used safely as human food.

A number of animal diseases as well as tuberculosis may be dangerous to men. Anthrax is a dramatic and deadly affliction which may be derived from infected cattle. It is, however, rarely found in the British Isles; here it is most commonly due to contaminated feedingstuffs imported from such countries as Africa and India where it is more prevalent. Trichiniasis is a disease which is common among pigs in the United States, where 5 per cent. of the animals are estimated to be infected. It is also seen in Germany and Poland. This complaint is caused by a small worm, *Trichina spiralis*, which is picked up by the pigs from infected food. The worm eventually bores its way into their muscles. Rats are believed to be the carrier for the parasite, and it is thought that the pigs become infected by way of rat droppings. The worm is killed by the heat of cooking. In 1941 an extensive outbreak of trichinasis occurred in the Midlands of England, where it is not uncommon for certain types of pork sausages to be eaten raw. The disease is a painful and prolonged one for human beings. It is difficult for a meat inspector to detect infected carcasses so that it must always be considered unsafe to eat pork, or meat products containing pork, raw or underdone.

The ebb and flow of the battle for scientific improvement, which those of us born before, say, 1914 once assumed to be a continuous advance towards better and better things, is shown up curiously by a recent minor, but none the less disquieting, success of one of man's ancient enemies—the tapeworm. The eggs of the human-infecting tapeworm, *Taenia saginata*, on being consumed by cattle, liberate a small embryo which works its way into the muscular tissue, usually the masticatory muscles of the jaw, of the beast. People who are unfortunate enough to swallow one of these 'encysted' embroyos in the meat they eat are liable to develop a tapeworm which can grow to a length of twenty feet and which in some instances has been known to live and eat with its reluctant host for thirty-five years.

The tapeworms saw their chance of imperialistic colonisation between 1939 and 1945, and the incidence of tapeworm infection in Europe increased considerably then. In Denmark, between three and four people per 10,000 inhabitants were treated for tapeworm in hospital. Five times as many women are infected as men, possibly because they pick up the worm cysts when they are handling meat in the kitchen. Tapeworms have also become increasingly common in Germany and Holland. The increase in Great Britain is due partly to the worms having been brought into the country by soldiers who have eaten unluckily while abroad, and partly by infected Germans and Italians pressed to work on British farms. Tapeworm infection among cattle is now widely scattered in all parts of Britain and Northern Ireland. Of all cattle arriving in Glasgow, approximately 1 per cent. are affected. While one can feel sympathy for animals afflicted with a human parasite, it is a salutary thought in this age of modern technology that a primitive, even old-fashioned, but nevertheless very disagreeable creature should have stolen a march on British humanity.

The list of possible kinds of infection capable of being acquired from meat looks forbidding when set down in cold print. In spite of Ministers of Food and Ministers of Health and even Ministers of Agriculture, and the growth of scientific knowledge, it is difficult to deny that the proportion of infected meat *may* have increased during the fifth decade of this century. Nevertheless, there are large numbers of competent people, ranging from the meat inspector who condemns an infected carcass to the foreman in a meat factory who has the courage to tell a workman to wash his hands on coming out of the lavatory, who are contributing to the struggle to maintain meat as a wholesome food. It is a consoling thought that, although there is sometimes a possibility that some of the meat reaching the market may be potentially dangerous to health, the overwhelming majority of it is sound food. Moreover, there are two potent defences against even the meat which is infected. The first is a good cook, the heat of whose oven can destroy many, if not all, the infecting organisms. The second, is man's natural resistance to abuse.

It may now be of interest to turn to one of the meat substitutes which has engaged a good deal of modern scientific thought. When we come down to the bare bones of basic nutritional principle, meat can be said to serve as a source of animal protein. As has already been mentioned, it provides much else, but this is its predominant function. In tropical countries, particularly in Africa and the West Indies, the native diet may be dangerously deficient in protein. The essential function which protein plays in the maintenance of of the human body is to provide nitrogen in a form which a higher animal, such as man, can make use of. Man cannot live on air, and cannot therefore make use of atmospheric nitrogen as food; but there are bacteria found on the roots of clover, peas, beans and other legumes which can utilise gaseous nitrogen and turn it into protein which men and animals can eat. Only slightly less simple than atmospheric nitrogen itself are inorganic compounds of nitrogen such as ammonia, ammonium salts and nitrates. Plants can assimilate these substances. The protein in meat is, therefore, a manufactured article depending on the uptake of nitrates or ammonia by plants, the consumption of the plants by a sheep, pig or ox and the further conversion of vegetable protein into animal protein.

This is an elaborate and expensive business. It is, therefore, not surprising that scientists in many countries, and notably in Germany, turned their minds to discover whether there was a short cut. They hit on yeast. Yeast is a plant which may be made to grow very quickly, and which is capable of making use of inorganic nitrogen and converting it into a protein with a composition possessing some of the valuable properties of meat protein. The speed with which yeast will grow is shown by the fact that each yeast plant can reproduce itself in less than two hours.

Yeast, then, can utilise inorganic nitrogen, for example, ammonia or ammonium phosphate, and convert it into protein.

In order to do this, however, it must be provided with a source of energy: that is to say, calories. Traditionally the starch in such grains as barley or maize was used to supply calories in yeast production. Early in the twentieth century, however, molasses, which are the crude residues remaining after the sugar crystals have been removed in the process of sugar manufacture, were employed. The logic of any plan to produce a yeast food to serve as a meat substitute depends, therefore, on the utilisation of inorganic nitrogen and cheap carbohydrate and their conversion into protein.

Although the most convenient cheap carbohydrate for yeast manufacture is probably molasses, yeast has also been made from other carbohydrates which normally feature less frequently as food even than molasses. The carbohydrates as a chemical classification may be separated into three groups. First, are the soluble sugars, including cane sugar (which is composed of sucrose), glucose, lactose in milk and a number of others. The second group comprises the reserve or stored carbohydrate starches. These are the most important source of food for man. They form the major component of bread, the rice of the east and the maize of Africa and America. The chemical similarity of sugar and starch becomes manifest when maize is boiled with dilute acid and hence converted into 'corn syrup'. The third group of carbohydrates are those which form much of the structural components of plants. A great part of the stiffness of a pine tree, for example, is due to cellulose, which forms this third carbohydrate group.

As we have seen, yeast has been fed on the soluble sugar in molasses and on the starch carbohydrate of cereal grains. It was not, therefore, a very long scientific stride to devise a procedure for feeding it on cellulose. Thus we have the engaging project of growing yeast on sawdust and ammonia, and from these two inedible materials creating a protein food equivalent, at least in some degree, to meat.

The economics of the primary production of yeast from wood used as a raw material are complex. Even when the fact that pine trees could be grown on land unsuitable for many other crops was taken into consideration, a recent calculation showed that it was doubtful whether the work and expense of converting the wood into yeast gave a yield of protein and calories any greater than could be obtained by planting the land with judiciously selected food plants. The matter is, however, very different when yeast is grown from waste material, or when existing yeast now thrown away as an industrial effluent is utilised.

Two different types of waste materials have been successfully used as carbon sources for yeast manufacture. The more important of these is sulphite liquor from paper manufacture. A recent industrial development, the large-scale production of rayon and such 'plastics' as bakelite, has also led to the existence of beechwood effluents in substantial amounts. Both these by-product effluents from wood can be used as the basis for yeast manufacture. Another source of yeast-calories is the lactose in whey, which is always available in large amounts in milk-producing areas where cheese is manufactured.

Considerable scientific ingenuity has been used in manufacturing food yeast. The usual strains of yeast employed by bakers and brewers belong to the Saccharomyces family. This yeast can comfortably utilise glucose or sugars such as the sucrose in molasses, which can be broken down into glucose. A different type of sugar called xylose occurs in wood and a different family of yeast, called Torula, can better cope with it. Other yeasts of still different races have been hunted up from the obscure media upon which they live in nature and pressed into service as a food for man or at least for the horses of the German military supply cadres.

During the decade 1940–1950, the scientific development of yeast as a protein source for man and hence, in part, as a supplement for meat passed beyond the stage of laboratory research and into the arena of large-scale factory production. In Germany, food yeast was produced from wood and from whey; at least one big paper company in Canada manufactured yeast from sulphite liquor; the United States of America's Forest Products Utilisation Laboratories were also at work; and the British Government built a factory in Jamaica to manufacture yeast from molasses.

Only one research problem remained to be solved before yeast could take its place as a nutritious human food. And that was to make it sufficiently palatable for people to want to eat it.

In the West Indies, the medical authorites tried to persuade the local inhabitants, whose diet was notoriously lacking in protein and in vitamins, to mix a small percentage of food yeast into their bread. The inhabitants, however, showed a marked lack of enthusiasm for it. In Germany, one big yeast plant marketed the whole of its output in 1947 in the form of flakes, partly to housewives, partly to factory canteens, hospitals and other large users and partly to food manufacturers. Unfortunately, the private users complained about the repulsive smell, attributed at that time to the residue of sulphite remaining from the wood pulp from which it was made. Another factory, with more success, mixed the yeast with equal quantities of sugar and concentrated whey to form a syrup the taste of which was claimed to be reminiscent of honey. A third firm made a species of 'meat paste' by mixing the yeast with casein from milk, fat and spices.

In spite of the ills that flesh is heir to, meat when compared with other articles of diet, is a reasonably wholesome food. Although the nutritional qualities it brings to the diet can be provided by other foods, for example, by milk and fish, its animal protein, iron and vitamins are prized by the medical expert. The medical expert has, however, done little about the development of modern meat technology. Indeed, he has allowed liver, the meat of all others of highest nutritional value, to disappear almost entirely from the British menu of the 1950's.

Where modern science has been applied to meat we find, as we have found in other contexts, that some of its results are good and some bad. The skill exerted in animal genetics and nutrition has produced a beast well suited to modern conditions. The understanding of muscle physiology gives good meat through proper handling of the animal during slaughter. Thereafter, however, scientific knowledge can claim fewer complete successes. Frozen mutton is very much better than no mutton at all, but is less good than home-killed meat. Modern large-scale cooking techniques, although enabling large numbers of people to be fed quickly, are less good than the practice of a good cook ignorant of the meaning of 'technology'. And, most humiliating of all, the foods which can from their composition take the place of meat have not yet been able to overcome a highly unscientific unpopularity when served at human meals.

The food scientist unfortunately has very little scientific to say about taste. For example, it is clear that the principal reason for including meat in a meal is because its *taste* is attractive, and strong custom has decreed that a meal is not a 'real meal' without a meat dish. It is true that the nutritional value of meat is important but it is not paramount in dietary affairs. Any nutritionist worthy of his keep could devise a combination of protein, fat and vitamins at least approximately equivalent to that to be found in beef steak. Yet when the British Ministry of Food issued its Statutory Instrument Number 1509 of 1948 declaring that the minimum meat content of luncheon sausage, breakfast sausage, meat galantine and polony might not be less than 30 per cent., whereas before the 1939 war a meat content of 80 per cent. had not been uncommon, they overlooked the fact that when the meat content of sausages is depressed lower than 20 per cent., the flavour of meat falls below the threshold of taste altogether and the manufacturer might just as well make his sausages with no meat at all.

Although the food scientists have little to say about taste, the physiologists have a good deal. Experimental rats have been shown to use their sense of taste to good effect to provide themselves with an adequate diet. When confronted with a number of pots containing pure protein, carbohydrate, fat and salts and with a series of twenty or so tubes containing individual vitamins and minerals, they have been found to select a nutritionally excellent diet. In an experiment done at Cambridge in 1944, a group of animals was given a choice of drinking a solution of sugar, a solution of alcohol, or of water in order to maintain their energy. When the sugar solution was exchanged for a similar tasting solution of saccharine (which is of no energy value), the rats maintained an equal calorie intake by drinking more alcohol.

Taste, however, is a fallible index of nutritional need even with rats. For example, they get used to eating out of a pot placed in a special position and will then fail to select more nutritious food placed in an unfamiliar part of their cage. Similarly with human beings, individuals become accustomed to certain tastes, to fixed meal times, and to familiar traditions. For a Briton, sour milk is nasty, and cream-cheese nice; putrid chicken is bad, but putrid pheasant good. Furthermore, people 'taste' with other organs than their mouth and nose. Not only can a blindfolded man not distinguish between a sixpenny cigar and a five-shilling one; he rarely knows whether either is alight or not.

4

Fish

The fish available in a modern industrial country today is not a particularly striking testimony to the technical and scientific skills which have been applied to its acquisition and treatment.

The first task of a food supplier is to supply food. The deep-sea fisherman does this with a steam or motor vessel which now takes the place of sailing craft with beam trawls. Every few years improved fishing gear is devised; otter trawls to sweep a wider area, 'bobbins' to ride on rougher ground, 'ticklers' to stir up the fish and, latest of all, radar and asdic to seek out the fish as they swim. Yet year by year the amount of 'prime' table fish on the market tends to become less, and the average quality of the total catch poorer. The effect of technical advance in the industry has been to make one fish swim where two swam before.

In 1866 a Royal Commission examined the effect of commercial fishing on fish stocks, came to the conclusion that this was negligible and recommended the abolition of all restrictive legislation. But by 1902 a falling off of the catch in the waters nearer home had become obvious and the matter was proved beyond doubt when the fishing holiday of World War I caused a sharp rise in catches for a few seasons afterwards. It is now no longer true that there are many more fish in the North Sea than ever came out of it. In 1907 British trawlers brought home 200,000 tons of fish from the North Sea, or 17 cwt. per trawler for each day's absence from port; in 1938 they caught 70,000 tons at a rate of 15 cwts. per trawler-day's absence. The catches increased immediately after World War II but are quickly falling again.

The technical advances in ships and gear and electronic devices for locating fish, which are leading to this steady diminution in the more accessible fish population, are the direct cause of a deterioration in the quality of the fish people get to eat—apart from the fact that the recent great inflation in operating costs has led to a simultaneous increase in its price. Over-fishing and depletion of the nearer fishing grounds have made it necessary to go to greater distances for fish. Iceland and the Faroe Isles were already popular at the beginning of the century, but in the 'twenties the northern Atlantic beyond the Arctic circle became warmer, the ice cap retreated and rich stocks of cod were found round Bear Island and in the Barents Sea. Instead of sending trawlers of 200 and 300 tons with crews of less than a dozen to fish for choice varieties round the British Isles—the average being about ten days—the Hull and Grimsby owners began building ships of 400 and 500 tons capable of carrying up to 30 men on voyages of over three weeks. Catches on these trips may be anything from 50 to 200 tons of fish.

Unfortunately, most of the fish caught by these 'mass production' vessels is coarse; three-quarters of it is cod and none of it is improved by lying for three weeks in a ship's hold particularly if, to save space, the fish is 'headed' at sea. Packing in crushed ice slows down decay, but only freezing can stop it; and freezing plant is expensive and frozen fish (and particularly frozen cod) is unpopular. It has already been pointed out in the technical press that Britain builds the best fishing ships and catches the poorest quality of fish with them.

For a number of years it has been obvious that the modern fishing industry is capable of catching more fish than the sea can produce. This has led to recurrent bankruptcies among fishermen and short-lived bouts of recovery among fishes, with consumers paying high prices for undersized fish scraped up from corners of the North Sea. In 1946 Britain proposed an internationally agreed limitation in fishing, but this was not accepted. The alternative is the present regime, in which cod from the distant Arctic forms the backbone of the dwindling fish supply.

That intelligence can be applied to the problems of national fish supplies is demonstrated by the example of fishery control on the Pacific coast. In this area, Canada and the United States agreed in 1932 to quantitative restrictions on landings to remedy over-fishing of halibut, and in a few years they found that it took only five months to gather up the same quantity of fish that had previously taken nine months. Apart from preserving their goose to continue laying golden eggs, the two countries were able to reap increased profits.

The fish-and-chip industry is a British peculiarity which might almost be said to have been created to consume the poor quality fish caught by the modern fishing industry. In Britain, fried fish-and-chip shops account for one-third to one-half of all the fish eaten; and they rely almost entirely on the cheap coarse varieties. There is still a small discriminating public remaining, but if all the fishmonger's customers were as easy to please as those of the fish frier, no one would pay enough money for soles, plaice, halibut and turbot to make them worth catching. As it is, six to seven times as much cod is landed as all the more palatable varieties put together.

Fish is an anomaly in the modern world by being the only remaining wild thing used by civilised man as a major foodstuff. All other foods, animal and vegetable alike, have been domesticated. Fish alone fends for itself without benefit of farm, pasture, fertiliser or (save for a few specialised trout hatcheries) purposeful breeding. It is, therefore, worth considering its food supply and biological origin, and it is also of interest to dwell for a moment on the theoretical possibilities which might arise if this anachronistic savage were, like all others, put to work for civilised mankind. Many unhappy precedents suggest that, if this does not take place, the alternative may be extinction.

Enough has already been said to show that the quality and kind of fish available to us in the shops depend on fundamental biological principles. Of these, the basic points are as follows. The supply of all food on land depends on the power of green plants to convert the energy of sunshine and the carbon dioxide gas in the air into the components of their own tissues. Similarly, in the sea, the existence of all life, with a few unimportant exceptions, depends on this same power of photosynthesis possessed by microscopic floating algae and some of the self-propelled flagellates which constitute the 'producer' plankton. The commonest of these organisms are the *diatoms*.

Because the diatoms in the sea behave like the green plants on land, they only grow in those layers of the water to which the rays of the sun can penetrate. Again like plants, diatoms require nitrate and phosphate as 'fertiliser' to enable them to flourish. In some parts of the sea the upper layers penetrated by sunlight do not get mixed with the deeper water for long periods. Under these circumstances, the nitrate and phosphate become exhausted and the flowering of diatoms dies away. On the other hand, where the sea is regularly 'ploughed' and the deep ocean water brought up to replenish the lighted top layer, a heavy and continuous growth of plankton occurs. These well 'manured' conditions are found in shallow water near the coast, in areas off West Africa and west of South America, where ocean water wells up, and where great rivers enter the sea. But by far the most important areas in which substantial and regular plankton growth is found are in high latitudes near the poles. Here the period of winter rest is followed by vigorous outbursts of growth. And so substantial are the supplies of phosphate and nitrate and other nutrient salts that after vigorous periods of plankton growth ample concentration of salts still remain. Thus the primary factor controlling the density of the fish population is the available supply of diatoms, and this supply is greatest in arctic waters and in certain other areas where the stores of manurial salts present in deep water are continuously available in the upper layer of sea penetrable by the sun's rays.

But just as happens with animals, not all fish feed solely on the elementary greenstuff of the ocean. Indeed, oysters, mussels and cockles are the principal commercial fishes which restrict themselves to diatoms. This is fortunate, because diatoms are highly impermanent and vast flowerings may entirely disappear in a short period of a week or two.

Swimming among the diatoms, which are 2 to 5 thousandths of a millimetre in length, are creatures whose size may vary from a half to 50 millimetres in length, and which prey upon them. These form the zooplankton. The length of life of the zooplankton may be from 2 to 10 months. They therefore form a more regular food supply for the herrings, mackerel and sprats which live upon them. Many other types of marine animals depend on zooplankton for their food, and these in their turn provide subsistence for the fish which come to market.

The fish we eat fall into the following two groups with the following food habits. First, the *pelagic fish*, herring, mackerel and sprats, which live for most of their lives on the zooplankton. In this they resemble the largest animal on this planet, the balein whale, which also lives almost exclusively on zooplankton. Then come the *demersal fish*, cod, haddock, whiting and flat fish, which form the bulk of the usual fishmonger's display. These feed, when they are young, first on diatoms, and later upon the zooplankton. As they grow up they change to a diet, first, of hermit crabs and other medium-size crustacea, and later to small fish, herrings and sprats. It is interesting to observe that all those species of fish upon which we depend for food are carnivorous. This is in contrast to the meat animals of the land which are vegetarians. (It should perhaps be said that Chambers's Dictionary defines 'pelagic' as 'living in the middle and surface layers of the sea', while 'demersal' means 'living at the bottom of the sea'.)

The difference in dietary habits of the pelagic and demersal fish explains the different methods employed to catch them. The herrings, which prey on the zooplankton in the upper water layers, are caught by curtains of two or three miles of netting, whose tops are supported by a series of buoys. Nets of this kind are called 'drift nets'. The demersal fish, which chase their food in the lower layers of the sea, are mostly caught by dragging a trawl over the ground.

A number of ways of increasing the yield of human food from the sea have been considered, quite apart from obvious steps such as the restriction of fishing to a level low enough to allow stocks of fish to replenish themselves naturally. In the past, for example, fish have been domesticated. Monasteries and other great houses kept carp ponds to supply their tables on Fridays and fast days. Today, farmed fish grown for the stocking of rivers are intended more for sport than for food. Manuring of selected areas of sea with the nitrates and phosphates upon which the plankton depend has also been suggested; but the economic difficulties confronting this procedure have so far proved insuperable.

There is one method, however, by which the total amount of human food to be obtained from the sea could be materially increased. This is for human beings themselves to eat the plankton upon which the fish feed. There is several times as much protein in the grass eaten by a cow as in the milk produced by the cow, even when supplemented by the cow's body turned into meat. However, although the protein can be successfully extracted from grass, forward-thinking scientists have not yet been able to prepare a human food from it which would seriously compete either with milk or with such meat even as cow beef. Could the enormous potential supplies of plankton be successfully exploited?

Diatoms are microscopic in size and are consequently difficult to collect in bulk. Furthermore, diatoms, although small, grow themselves what can loosely be described as a shell; and, even when they are collected, they consequently form a foodstuff unduly high in mineral content. A less scientific but infinitely more cogent objection to diatoms as a food for humans rather than for fish is that they taste disagreeable to the human palate. Zooplankton, on the other hand, comprises animals something larger than microscopic and it can be collected with a fine stramim net. Indeed a serious proposal, backed by a small amount of practical investigation, has been made to collect zooplankton by means of a series of such nets set up in Scottish lochs through which the tide runs swiftly. Unlike diatoms, zooplankton is pleasant to eat and possesses a taste strongly reminiscent of potted shrimps. It also contains 10 to 30 per cent of fat and a satisfactory content of vitamin A. In spite of these attractions, however, the inconvenience of capturing it have discouraged people from exploiting the potentially greater yield, and they have up till the present allowed the fish to collect the plankton and then continued to pursue the fish.

The prize for the nation that first works out a method for collecting and marketing plankton as human food would be great, and the novelty of the idea may have induced governments and administrators to turn away from it too easily. It has been calculated that an area of a hectare (about 2½ acres) of the South Georgia Sea would yield an annual crop of 31 tons of plankton; the crop from a hectare of the English Channel is estimated at 14 tons. The same area of cultivated mussel beds gives 8 tons of food a year, and an uncultivated mussel bed yields about 4 tons. The yield from carp ponds has been reported at a figure ranging from a ton to a hundredweight per hectare of area. In comparison, the amount of food 'cropped' as fish from a hectare of the North Sea is less than 50 lb.

It is with some unavoidable feelings of bathos that we turn from stimulating speculations of what might be to a consideration of things as they are. Great Britain is an island no part of which is more than a hundred miles, or, say, three hours' journey from the sea. Yet the mammoth organisation of national food distribution is still incapable of providing customers with more than a part of their fish in fresh form.

A modern citizen is instructed to complain to his coal-merchant if he finds stone among his coals. Equally, the citizen's wife is told only to buy fish the eyes of which 'should be bright, clear, full, moist and not wrinkled or sunken', the flesh of which 'should be elastic and firm', and the gills of which 'should be fresh in colour'. 'The scales should cling tightly to the skin and have a sheen and the natural colour of the fish should be bright and clear, not faded'. Alas! Many fish on the fishmonger's slab and many more which achieve the apotheosis of the fish-and-chip shop do not attain these standards. By the time they are consumed, they are stale.

It should perhaps at this juncture be stated that stale fish is not undesirable because it is harmful to health. It is undesirable because in the opinion of most civilised and perceptive people its taste is less agreeable than that of fresh fish. The deterioration starts in the fishing vessel. We have already discussed the reason why trawlers, for example, go off on expeditions of up to a month's duration. The fish, even though they are packed in ice, are not kept at a sufficiently low temperature to stop the progress of decay. Furthermore, precautions to keep them clean and thus reduce to a minimum initial bacterial contamination are rudimentary in many ships.

The decay of fish, like meat, is primarily due to bacteria. As soon as this fundamental point is appreciated, it can be recognised that the standard, 'returnable', market fish-box made of wood forms an excellent reservoir of bacterial contamination. It should be said, however, that a few of the more advanced firms dealing in fish have taken notice of this point and are introducing alternative containers which it is possible adequately to clean after use.

The research station at Aberdeen belonging to the British Government has been to some pains to work out the changes occurring in fish which are packed in ice when they are caught. This knowledge is half the battle, although the remainder of the campaign—discovery of a method to supply consumers with fresh fish—has not yet been brought to a successful conclusion. The fish researchers, however, can take heart in the fact that the medical scientists have, at the time this is written, only succeeded in infecting ferrets with influenza; the achievement of curing influenza in man still eludes them!

Fish is more perishable than meat, and the temperature of 32° to 34° F. normally provided by crushed packing ice is not sufficiently low to prevent quite rapid bacterial spoilage. Experienced tasters can detect the difference between freshly caught white fish and those stowed in ice for two or three days. Less discriminating people do not notice incipient decay until a period occurring between the seventh and the eleventh day. During this phase there is a rapid production of trimethylamine from the action of bacteria which at the same time are breaking down the fish protein. This substance, together with ammonia, sulphuretted hydrogen and indole combine to produce the unpleasant, characteristic smell of stale fish. The flesh simultaneously becomes softer.

During the next phase, from the eleventh to the fifteenth day, there is a rapid deterioration in appearance and smell and after about the fifteenth day the fish can hardly avoid being described as putrid. It can be seen from these facts that the disposal of fish caught during a long voyage of three or four weeks to the polar seas or the tropics demands a highly organised system of distribution when the trawler reaches port.

The unpalatable substance in stale fish survives cooking. The *raison d'être* of the fish-and-chip industry, therefore, becomes clearer when it is observed that frying is as effective as any method in masking stale flavours.

Herrings, like other pelagic fish, are caught in drift nets comparatively near the coast in voyages which are usually of only overnight duration. They are not customarily stored in ice, nor are they gutted. The retention of their viscera and their fatty composition makes them particularly susceptible to rapid deterioration. For example, a gutted haddock will remain in reasonably good condition for about a day at 60° F. but will be definitely distasteful after two days. The corresponding times for ungutted herrings are of the order of half a day and 1½ days. Even with the short catching voyage, it is hardly possible for an urban consumer to expect to eat his herring within the half-day period during which time alone the discriminating fish expert is prepared to vouch for its freshness. Practical trials have shown that herrings treated with plenty of ice remain 'almost as good as fresh' for about three days and in a condition not regarded as definitely stale for a week.

When cod-liver oil was first introduced as a prophylactic for rickets, its taste was extremely unpleasant because the cod's liver was allowed to become rancid before the oil was extracted. When more was discovered about the action of cod-liver oil, it was found that, during the onset of rancidity, vitamin A, one of the substances upon which its therapeutic action depends, was completely lost. Since that time, steps have been taken to extract the livers while they are still fresh and, in consequence, modern cod-liver oil is not only a better prophylactic agent, it is also a palatable oil. In the instance of the herring we were discussing above, it is unfortunate that we have no knowledge of the effect of staleness on its nutritional value.

Enough has been said to show that a very great deal has been discovered by scientific workers of the nature of the changes occurring when 'wet fish' is stored in ice. Details of the changes in muscle chemistry have been worked out for fish as for meat, and it is clear that a dead fish would keep better if it would only refrain from struggling while it was being caught. The nature of the bacteria which bring about putrefaction has been studied and the route by which they progressively invade the fish. Following from this work, at least two experimental trawlers have been built in which the fish are washed and gutted and packed in clean boxes immediately they are caught. In comparison with fish piled into the ship's hold in the customary manner, the first-caught partly crushed and contaminated with water dripping from the later fish stowed above, all to some degree spotted with blood, slime, faeces and mud, it was found that expert judges considered the experimental fish to be 'fresh' after 6 or 7 days in ice whereas the normally treated fish were 'stale'. Later on still, the experimental fish were rated '6 to 7 days caught' when in fact they were '10 to 12 days caught'.

In brief, the patient (and expensive) scientific investigation of fish as food has told the fishing industry that they can improve the quality of the fish the consumers eat and can increase the saleable proportion of their catch if they are prepared to take the trouble to maintain a high standard of 'good housekeeping'. Under the conditions existing at present, fish is not considered to be 'really fresh' if it has been kept in ice for more than a week although a few more days can pass before it becomes 'definitely stale' in the eyes of the trade. Part of a trawler's catch may comprise fish which has been stowed for periods ranging from six to eighteen days, and one-half of such fish may be 'definitely stale' or worse. The quality of the demersal fish landed varies all the way from 'perfectly fresh' to 'unfit for human consumption', and about 2 per cent. on the average is actually condemned at the port.

In spite of the dubious economic health of the fishing industry as a whole, the reasons for which have already been mentioned, some steps are being taken, albeit hesitantly, to improve practice—for example, by investigating the suitability of various types of metal and plastic materials for ships' holds, fish pounds, shelves, containers and other equipment. Efforts are also being made to find a more effective preservative than ice, but as yet this problem remains unsolved. The most promising alternative is perhaps carbon dioxide. This material, although a gas at normal temperatures, can be obtained as solid blocks in which form it is a powerful refrigerant. It has been found to be an effective bacterial inhibitor for fish when it is used in conjunction with normal storage in ice in sufficient amount to exceed 40 per cent. of the atmosphere. Obvious practical problems would require to be solved before carbon dioxide gas storage could be employed in a fishing vessel, but similar difficulties have been overcome. Unfortunately, although carbon dioxide will delay the onset of putrefaction by at most about five to seven days, the fish, although not developing any unpleasant smell, frequently become soft in texture and of poor, unattractive quality during their extended 'life'.

A number of chemical preservatives have been tested but so far there has been objection to all of them. Some produce undesirable changes in the appearance or flavour of the fish; some corrode the walls and fittings of the ship's hold, or destroy the containers into which the fish are placed, and most of them are very properly prohibited by food and drug regulations. Although the food chemist may feel affronted by the intractability of the technical problem of embalming fish and yet retaining their edibility, the consumer may not be displeased at the knowledge that, if the fish he eats tastes fresh, it probably *is* fresh, although the price he pays for this knowledge is the presence on the market of a good deal of stale fish.

If modern scientific technology has not so far elaborated a new chemical method for making fish less perishable, two traditional methods still retain a modest popularity: these are smoking and salting. The only smoked fish appearing in any quantity on the modern dining table are kippers and haddocks. A dwindling rearguard of other varieties persists, but only as a vestigial remnant; smoked salmon is too aristocratic, and bloaters and 'smokies' are too vulgar. In 1939 about 30 per cent. of all the haddocks landed in Scotland were smoked and about 20 per cent. of the herrings were kippered.

The process of smoking consists of hanging the split fish, or fillets taken from them, in an atmosphere of warm wood-smoke or peat-smoke. Before the smoking begins the fish are dipped for 10 to 20 minutes in a strong salt solution which may or may not contain dye. The quality of the final product in the eyes of the consumer depends on the 'point of finish' of the smoking. Haddock, for example, may be produced as a 'pale' which is lightly cured or as a 'finnan' which is more heavily cured. Although the flavour of the resultant product depends on the length of cure and the type of fuel from which the smoke is produced, the fundamental purpose of the process is to preserve the fish.

Surprisingly little is known about the chemical nature of wood smoke. It has long been considered in the trade that, of the hard woods, oak produces the best colour and flavour and that soft woods such as pine and spruce result in rather acid, acrid flavours and smells. The active constituents of the smoke, however, appear to be phenols and aldehydes plus tar and a number of other compounds. Phenol itself is the common substance carbolic acid, and of the aldehydes, formaldehyde is popularly known as the agent with which medical students preserve the frogs they are dissecting. Commercially cured 'finnan' haddocks contain approximately 100-200 parts per million of formaldehyde and kippers contain up to 1,000 parts per million, that is to say 0·1 per cent.

The joint result of the drying that takes place during the smoking process, the formation of a surface pellicle due to the action of the smoke and the coagulation of the superficial layer of protein, and the bactericidal effect of the phenols and aldehydes from the wood fumes is to increase the time during which the kippers and haddocks can be kept in reasonable condition at normal atmospheric temperatures up to about three days. Storage at freezing temperature is extended to about twenty days.

Although a number of minor changes in composition occur during the smoking of fish, many of which are of course due to drying, in general the food value of the processed fish is similar to that of the fresh untreated fish. The basic purpose, as has been said, is to postpone decay; the change in flavour, which opinion may or may not construe as an improvement, is incidental. The manufacturer who uses a dye, instead of long smoking, to give his product the appearance he believes his customers desire must, of course, cure the fish properly with brine if he is to obtain the improvement in keeping quality. The customer, although he is deceived, is not deprived of any nutritional element he might legitimately expect to get in a fish darkened exclusively by smoke. His loss is in flavour—a matter in which tastes differ. He also buys slightly more water.

The coming of the steam and motor trawler, the introduction of ice storage and the development of rapid transport increased the supply of fresh fish to all parts of Great Britain. This led to a decrease in the popularity of smoked fish and more particularly of brine-cured herring. The gradual extermination of fish in accessible waters and the consequent need for the exploitation of distant fishing grounds with a resultant return to the commonplace of stale fish might, if it were ever possible to put back the clock, be expected to revive the consumption of cured herring. But, like brown bread, they once upon a time acquired the stigma of being considered to be the food of the poor. It is unlikely, therefore, that the British population will be prepared to readjust its dietetic values, and we may expect to see the present export of the greater part of the salt 'cure' continued.

It is said to be impossible to make a man virtuous by Act of Parliament and it was found equally difficult during World War II for the Ministry of Food to direct the British public to eat salt cod. This material is prepared by splitting the fish and piling it up, salt being interspersed between the layers. The 'green' cure obtained in fifteen days is left lying in 'wet stack' for a month or two. It is then hung up to dry and finally packed in cases or bales. The food technologist, laboriously seeking for a way to prevent fish going bad, laments the fact that his neighbours today do not like salt cod. He cannot forget that the dried product will keep from four to six months without refrigeration, and even cod in the 'wet stack' will keep for two to three months.

He may equally regret the unpopularity here of cured herrings. These, after gutting, can be packed into barrels with salt between the tiers. After a few days, the juice is run off, more herrings in the same state of salting are packed in, and the barrel finally topped up with the original salty juice or 'pickle'. This fish will also keep at normal temperatures for three to four months. It is accepted in many European countries, where the *matja* herring is regarded as a delicacy, but not by the palate of the modern, machine-age Anglo-Saxon.

Those who try to apply the technical developments of the age to food and particularly to fish have much to contend with. It could have been hoped that, even when the uncertain temper of the age had refused *dried* cod, it would have embraced cod *dehydrated*. The process of dehydration, when carried out by means of modern machinery, produces a drier product than can be achieved by traditional methods, and the quick destruction of enzymes retains to a greater degree the flavour and texture of the original fish. Finally, the heating before and during drying gives a material already cooked which can be prepared for the table merely by adding the appropriate quantity of hot water.

We have already agreed that prime home-killed mutton is an aesthetically superior article to frozen imported mutton. If both are minced, however, no one will give a fig which he eats. There is a tenuous consistency about mankind. Dehydrated fish is an excellent article. It will keep for a year; it retains the flavour of the fish it is made from; and its nutritional value is impeccable. One weakness only can be laid to its door: it is all minced up and can, therefore, only be used for fishcakes.

There are two ways in which fish can be preserved and yet still remain popular. The first is by adequate freezing and cold storage. We have already seen that storage in ice, which gives a temperature approaching freezing, only prolongs the useful existence of fish for a limited period. Even the normal cold storage temperatures of about 18° of frost (*i.e.*, 14° F.) is ineffective for more than a short time. Fish stored at this temperature soon develop a variety of undesirable qualities. Cod and other white fish become 'sloppy' or dry in consistency and have an odd, characteristic 'cold storage' flavour. Fish such as herrings, which contain substantial amounts of fat, develop a rancid flavour. Since salt accelerates this process, kippers become rancid in cold store sooner than herrings. The surface of fish in cold storage tends to become spotty and, since drying is constantly taking place, in time toughened, wrinkled patches appear on the surface. This is the so-called 'freezer burn' which also occurs in meat. Evaporation can be prevented either by using moisture-proof wrappers or by glazing the fish with ice. Because of all these troubles it is only possible to keep fish for about a month under customary cold-storage conditions. Kippers will only survive for two to three weeks. Only if a lower temperature is used, say 50° of frost (*i.e.*, −18° F.), and the fish are frozen quickly can a really good product be expected after a few month's storage.

The second successful method of preserving fish is canning; and canning is successful in many respects. Canned fish will keep for five years at least without deterioration and without the necessity for special storage. Certain kinds of canned fish which are packed in oil will keep safely for ten years. But the special technical achievement of the fish canner is that he can produce something quite new, different from nature and often, many would say, better. If Rip-Van-Winkle woke up and was given a tin of sardines for the first time, he could not fail to believe in progress and the useful inventiveness of man. Scotch salmon is a fine food eaten once in a while, but good quality canned salmon also has many merits and fits less obtrusively into the regular pattern of the daily diet. Furthermore, the nutritional value of canned salmon, particularly as a source of calcium, is superior to that of the fresh variety because the heat to which it is subjected under pressure during the process of sterilisation softens its skeleton to such a degree that it is possible, and indeed agreeable, to eat the backbone.

In reviewing the supply of fish to the modern civilised world we have, therefore, cause to reflect on the factors which tend to a diminution in supply and a deterioration in quality.

On the other hand, there is cause to hope, first, that some sane international body may take thought of the problem as a whole and may persuade the maritime nations who catch the fish to do so with due regard for good husbandry. If this comes about and economic stability for the fishing industry follows, we can expect to see an improvement in 'good housekeeping' and more fresh fish. Secondly, perhaps, the scientists and technicians may, as a result of their devoted labours, produce a new food as delectable as smoked salmon but as cheap as sardines.

5

Chicken

SHAKESPEARE talks of the sixteenth century Justice 'with fair round belly, with good capon lined'. In the nineteenth century, Dickens describes a 'devilish good dinner—cold but capital—peeped into the room this morning—fowls and pies, and all that sort of thing'. In mid-twentieth century Britain, however, poultry has become a rarity on the urban dining table: its price puts it beyond the reach of the ordinary family—except on special occasions like Christmas Day. Supplies of poultry exist in Britain, and in substantial quantity, but they are consumed largely by hotels and caterers; and, in any event, the amount is negligible in comparison with the size of the population.

Poultry have been purposely suppressed in Britain as a matter of reasoned policy. This policy has been widely, but not unanimously, accepted by those who have considered it. It is, therefore, worth reviewing the facts and trying to assess the justice of the decision.

The first obvious point is that much of British agriculture is a processing industry. This applies particularly to poultry. Chickens eat imported grain, from which they obtain their energy, and they eat fish meal or other sources of protein from which they acquire the ingredients necessary for growth. Their consumption of both these foods competes directly with that of other livestock; and they also compete directly with man. When a cow eats grass she does not compete immediately with a man who does not eat grass. This statement, however, is not completely true, since, if the field in which the cow is grazing were ploughed up it could be used to grow potatoes or grain which the man *could* eat. The statement is truer for a sheep on a rough hill pasture unsuitable for arable crops, but not entirely true even in this instance because the sheep must be fed in the winter on crops grown on land where human food could have been grown instead.

British agriculture will retain its characteristics as a processing industry as long as the standard of diet is higher than could be achieved solely from the production of the country's own land. Reference has already been made to Professor McCance's investigations of 1941, in which he showed that a diet of brown bread, vegetables, milk and little else could have provided all the physiological needs of the British population, with an immense saving in agricultural land. The Government of the day, whose science was politics, 'the art of the possible', and not physiology, chose to plan the British diet on a wider and more humane basis. Their doing so involved the necessity of a calculated volume of imports. And in applying the logic of planning to the allotment of these limited imports they conceived that the facts warranted the virtual extinction of poultry as a general article of diet.

The facts to be judged are complex and, as we have seen, the basic premises are confused, being partly physiological and partly psychological. The psychological basis for argument is that no civilised population could be expected to live on a basic peasant diet, no matter how well balanced nutritionally. The physiological basis is that when the stipulated aesthetic level has been achieved, the diet must then be made nutritionally adequate as economically as possible. It is difficult to assess the considerations by which the place of chicken in the aesthetically minimal diet was judged and found wanting; and in studying the nutritional evidence, we cannot separate fowl from eggs. It therefore follows that if home-produced eggs had achieved nutritional respectability, chicken would also have survived as a by-product.

The shortage of animal feeding-stuffs, particularly concentrates, led the British Government shortly after the outbreak of war in 1939 to assign an order of priority to various classes of farm livestock for such feeding-stuffs as were available. Several factors appear to have influenced the final decision, among which may be named the relative efficiencies of the various animals as converters of feed into human food, the need to maintain soil fertility, the fact that some foods normally fed to pigs and poultry largely consisted of materials available for direct human use, and the fact that at the time the decision was made eggs and bacon could still be obtained from the Netherlands and Scandinavia. As a result of these considerations, the final order of priority was, first, dairy cows as milk producers; second, sheep and beef cattle; and third and last, pigs and poultry.

It is interesting to recall that during World War I another British Government faced with a similar situation placed the order of priority as, first, working horses; second, dairy cows; third, breeding stock; and fourth, pigs, poultry and breeding ewes. No provision was made for fattening sheep or cattle.

Obviously an animal cannot produce in the form of its own flesh or as milk, eggs or progeny, as large an amount of calories and nutrients as is contained in the food it eats. Part of its food goes to satisfy its own living requirements. In order to assess the relative efficiency of different types of livestock, the agricultural scientist must, therefore, study the percentage dividend of calories, protein, vitamins and the rest paid by the animal on the 'capital', in terms of feed, invested in it. The best average figures available, calculated in 1946, show that pigs produce meat containing 20 per cent. of the calories of the food fed to them; dairy cows return as milk approximately 15 per cent. of the calories they eat; hens give back 7 per cent. of their calories as eggs and 5 per cent. as poultry meat; and, least efficient of all, cattle and sheep only yield as meat 4 per cent. of the calories in the rations they consume.

It is interesting to observe that whereas the amount of inedible material, largely bone, in a leg of mutton represents 52 per cent. of the weight purchased, the amount in a turkey is on average 54 per cent. and in a roasting chicken 60 per cent. Thus when one pays a 1951 price of 3s. 9d. a pound for chicken, the cost of edible food is 9s. 4d. a pound.

Calories are basic to diet; the ultimate result of caloric deficiency is hunger and starvation. Chicken, however, cannot appropriately be judged solely on the return of calories it represents although, as we have seen, it is by no means the least efficient of feed converters. In the cold light of nutrition, chicken is a source of animal protein. Careful calculations were made in 1939 and 1941 by the School of Agriculture of Cambridge University and the Imperial Bureau of Animal Nutrition in Aberdeen and it was concluded that for each 100 lb. of digestible feeding-stuff protein fed, the dairy cow returned 35 lb. of animal protein for human consumption, the hen gave approximately 30 lb. as eggs or 20 lb. as meat, the pig gave 20 lb. and the bullock and the sheep 8 to 15 lb. Here again, the hen acquits herself creditably.

Of the minor nutritional components of diet, calcium cannot be supplied adequately by any combination of vegetable foods which Western peoples could be expected to eat, although the expedient of adding chalk to flour has had successful nutritional results. Milk and food made from it, such as cheese, are by far the best natural source of calcium. Yet, although poultry can make no claims to compete with dairy products as a source of calcium, they are predominant as suppliers of iron. The iron needs of the body, it is true, can be met adequately from vegetable sources alone if the foods are properly selected, but animal products represent the most convenient way of obtaining dietary iron, particularly when the needs are largest. For each 1,000 calories of food they eat, hens return as eggs 1·2 milligrammes of iron or 0·5 milligrammes as poultry meat. Dairy cows produce 0·9 milligrammes of iron as milk and pork 0.8 milligrammes, whereas beef and lamb yield 0·4 and 0·3 milligrammes respectively.

As a source of vitamin A, hens in supplying eggs are markedly superior to their nearest competitor, milk, on a basis of calories of feed consumed. All other animals are negligible suppliers. While eggs and milk are important dietary constituents from the standpoint of vitamin A, it is possible to satisfy the body's needs of this substance with the so-called 'pro-vitamin', carotene, present in vegetable sources, of which carrots are a notable representative.

Riboflavin is another important vitamin. It is very difficult to get adequate supplies of riboflavin from vegetable foods. Of the animal foods, milk represents the best return on food fed, followed by eggs, pork, poultry meat, lamb and then beef, in that order.

Finally, in the list of the significant food components, we come to vitamin D, the rickets-preventive vitamin. For the large amounts needed by children in countries in which sunshine is scarce we must depend on such exceptional sources as cod-liver oil. Among normal foods, however, the hen in supplying eggs produces 42 *international units* of vitamin D per 1,000 calories of feed compared with the cow's 6 *international units*. No other animal produces any.

These facts put poultry in a better light than would have been expected in view of the virtual sentence of death passed on them by the British planning authorities during World War II and thereafter. On the basis of a return of nutrients for food fed, poultry, which yield both eggs and meat, come second in efficiency as compared with dairy cows. This conclusion is susceptible to more or less precise mathematical proof.

The argument that cows and sheep eat grass, whereas hens eat wheat and maize which can also be eaten by man is open to more diffuse and partisan argument and less precise arithmetical measurement. It is difficult to calculate what difference it would make to the total supplies of food if a given number of cows were eliminated, the amount of feed concentrate they eat transferred to poultry, and the grass-land they occupy devoted to arable crops for human consumption. Related to this calculation is the further one needed to decide what effect, whether good or bad, such a change would have on the permanent fertility of the land.

Although the types of crops to be encouraged were specified in detail by the central governing authority during the war years of the 1940's, the figures upon which decisions were based were not presented for public discussion. Clearly, the decisions were not made solely on the relative efficiency of production of nutrients. As we have seen, other criteria—for example, views as to whether individual articles were 'luxuries' or 'necessities'—also came into the question. Among the agricultural products chosen, milk—and tobacco—were rated as 'necessities', whereas chicken and locally made cheeses were classified as luxuries. Further criteria were the suitability of soil for the production of certain commodities and, a point carrying weight with the precise-minded Anglo-Saxon administrator, whether a commodity, when produced, could be easily controlled and prevented from becoming an article of barter. Chicken—and eggs—fall down badly under this test.

Because the arguments are, perforce, based on such tenuous reasoning we may expect to see agricultural priorities changed from war to war.

During the fifth decade of the twentieth century the amount of feed concentrate allowed to poultry producers in Britain varied from one-eighth to one-fifth of the amount they were accustomed to use before. In spite of this, however, by the end of the period the number of birds was approaching the pre-World War II figure. But apart from the change in the types of food available for conversion into poultry products, it should be noted that, whereas in 1939 Canadian wheat suitable for poultry feeding was available on British farms at £5 a ton, in 1949 'non-millable' wheat cost £25 a ton.

The change in feeding technique has been interesting. In 1939, poultry were fed intensively on highly concentrated foods such as maize and wheat, and a high efficiency of utilisation was obtained. These energy-feeds were 'balanced' by proteins, notably fish meal. In place of these, bulky watery foods, for example, potatoes, carrots, house-scraps and 'industrial pudding' made from processed house-scraps came into use. These vegetable foods were employed to supply up to half the total ration. The unsatisfactory feature about them was that all of them were deficient in protein. They were at times supplemented by fibrous foods, oat and barley husks, dried grass and similar materials. Although these unrationed foods were often used to an appreciable extent they were probably of little value since birds cannot cope successfully with bulky materials of this nature.

Because little imported feed was permitted for poultry production, the decision was taken to encourage general farmers to keep poultry and to feed the birds on their own home-grown cereals. This decision must have been reached after the most delicate balancing of competing advantages. On the one hand, the professional poultry producers, who often operated on a substantial scale, were able to obtain a high efficiency of conversion of feed into eggs and poultry meat but had to purchase their supplies of feeding-stuff. On the other hand, the general farmers who kept a few miscellaneous fowls for their own table were able to increase the numbers of their birds without apparently needing to use feed which would otherwise have reached the market. Be that as it may, the controls on a farmer's use of grain were relaxed, so that by 1950 he was allowed to feed unlimited barley and 20 per cent. of his wheat to his own poultry.

The result was that, whereas previously poultry had been produced in the industrial areas of Britain, production shifted to the grain-growing areas of the north and east. In Scotland, there has been a tremendous development in the north-east, especially in such counties as Aberdeen, Sutherland and Banff, where an increase of over 40 per cent. occurred between 1939 and 1946. This swing, while principally due to the encouragement of the use of home-grown cereals, was also due to the fact that planned administration had produced results different from those of the natural play of economics. Before the advent of detailed administration, areas remote from large consuming centres received a poor average price for their eggs and poultry, especially in the Spring flush season. But under the Ministry of Food's packing station system they enjoyed an assured market and guaranteed prices. Thus it happened that the largest single packing station in Britain was established in Orkney.

In order to produce poultry efficiently an adequate supply of protein is essential. The acute shortage of meat meal and dried skim milk is only partially overcome by small supplies of other protein food. As has been mentioned, the best of these is fish meal. Grass also provides good protein, and poultry which are able to range over plots of young grass derive useful nourishment therefrom. Dried grass meal is produced in limited amount and, although containing more fibre than is suited to poultry, provides protein. Farmers use bean meal and pea meal as home-grown proteins; both are quite useful and may form up to one-tenth of the total ration.

Two interesting technical developments have taken place as an incidental result of the shortage of protein for poultry feeding. In order to relieve the shortage, vegetable protein, which is easier to obtain than animal protein, has come increasingly into use. Soya-bean meal and ground-nut meal are two commodities which have been employed extensively.

When vegetable diets of a somewhat exiguous nature were used for long, two deficiency diseases unexpectedly appeared. The first disease was fatal. It was a failure of eggs to hatch. The embryos grew and developed up to the twelfth or fourteenth day, and then died. It was eventually found that this was due to a shortage of the vitamin, riboflavin, in the diet of the hens. A second disease, which was later discovered also to be due to riboflavin deficiency, affected growing and adult birds. It was called 'curled-toe paralysis' because of the characteristic 'clenched fist' appearance of the feet. Under normal circumstances riboflavin could be supplied in the form of dried yeast or dried grass meal. Both of these have become scarce, but it seems as if a technical solution may have been found to make good the shortage.

In 1935, a French bacteriologist studying fungus diseases of the cotton plant in French colonial Africa noticed that the infecting organism, *Eremothecium Ashbii*, produced large yellow spherical granules when observed under the microscope. He had the curiosity to wonder what the chemical nature of these granules might be, and in a short time published the fact that they were composed of pure riboflavin. Thereafter the big chemical firms got to work and in due course developed a process, not dissimilar from that for the manufacture of penicillin, for the large scale growth of the organism and the collection of riboflavin from it. Today, this source of riboflavin is probably the cheapest on the market and is soon likely to provide sufficiently large quantities to supplement much of the poultry feed required by the professional poultry producers.

A second deficiency condition was discovered when birds were fed on a vegetable ration in which the protein was provided by soya meal. These birds did less well than those given meat meal or a variety of other animal protein foods. At first, the substance lacking in the soya meal diet was called the 'animal protein factor', but later it became clear that it was either a new vitamin called 'vitamin B_{12}' or something closely related to it.

In 1926, Minot and Murphy, American research workers, made the important discovery that people suffering from pernicious anaemia could be kept alive if they ate large quantities of liver every day. The consumption of all this liver was troublesome and nauseating but it was unavoidable until it was found that the liver could be concentrated and the concentrate injected. In 1948, the active substance in liver was identified simultaneously in laboratories in England and America and was called vitamin B_{12}. It is this substance which enables chicks to grow rapidly and to attain full health and vigour.

Vitamin B_{12} is peculiar in two respects; it contains the metal, cobalt, and it is coloured red. Its importance as a therapeutic agent and nutrient again set a problem to the great pharmaceutical manufacturers. This problem was ingeniously solved when it was discovered that the residues of the fungus which is used to produce streptomycin, and which are normally discarded, contain substantial amounts of vitamin B_{12}. We thus have a second example of a vitamin necessary for the welfare of poultry being produced in bulk by a fermentation process, but on this occasion the fermentation process did not have to be elaborated specially for the purpose but was already in existence.

The manufacture of substantial supplies of low-priced concentrates of riboflavin and vitamin B_{12} (or the closely related 'animal protein factors' which appear to be naturally associated with it) will make it possible to feed large numbers of poultry on cheap diets in which the protein as well as the energy are derived from vegetable foods. It is possible, therefore, that one day chicken may reappear as a normal article of diet in the towns of Britain.

6

Eggs

In the early 1940's, a prominent scientist attached to the Ministry of Food in London dropped the remark that stale eggs were, on a nutritional basis, as good as fresh eggs. On a nutritional basis, this was true; but the information was not received with very much enthusiasm by the consuming public.

Under commercial practice, eggs can be stored at about 29°–32° F. for periods up to nine months during which they remain in a state not grossly dissimilar from fresh eggs. Since an egg is an unstable system, the object in storage is to delay or arrest the natural changes and to prevent harm by external agencies and particularly by invading micro-organisms. It is important that normal changes should be prevented quickly in eggs that are to be stored for long periods, for not only do they proceed at an increasing rate once they are under way, but they also facilitate attack by bacteria and moulds.

One of the first things to happen when an egg is stored is a loss of carbon dioxide gas. This loss has several remarkable effects. An earlier name for carbon dioxide was carbonic acid; its removal, therefore, makes the white of the egg less acid. Most bacteria grow best at the degree of acidity of a fresh egg. In order to defend itself, therefore, the egg is provided with a natural antiseptic substance. When the acidity of the white drops, as the egg gets staler, it becomes slightly less acceptable to infecting bacteria, with the unexpected result that the germicidal activity of the white actually increases.

But the loss of carbon dioxide has other and less desirable effects. Protein is very susceptible to changes in acidity. If a man 'overbreathes' for some few minutes—that is, if he pants artificially and thus sweeps carbon dioxide out of his blood, its acidity will fall just like the egg's and he will eventually have cramps. These cramps are due to a change in the state of his muscle protein resulting from the reduced acidity of the blood. Similarly, the loss of acidity produces the difference in the nature of the white of a stale egg compared with that of the white of a fresh egg. The scientific attempt to prevent this change is 'gas storage', which involves the introduction of a proportion of carbon dioxide into the atmosphere of the warehouse.

An egg is naturally provided with an air-space at its larger end for the convenience of the chicken which the hen optimistically imagined it would one day contain. As the egg becomes older, it loses water by evaporation and the size of the air-space increases. This is not harmful in itself; but since it is associated with the other changes due to staleness, it is commonly taken as a sign of poor quality. When eggs are graded at a packing station, they are 'candled'. Candling consists of holding the egg in front of a circular opening into which it roughly fits and behind which is placed a lamp. Since the shell is translucent, the strong light shining behind the egg in an otherwise darkened room enables a good deal of the egg's internal structure to be seen. The size of the air-space is one of the first things to be looked for.

Eggs stored under refrigeration tend to lose water, and the air-space in them consequently increases. Even if the cold store is kept damp, with a relative humidity of 85 per cent., considerable evaporation occurs, and they would, therefore, be rated stale by the end of nine months. If the humidity of the store is raised sufficiently high to prevent evaporation, mould is likely to grow on the outside of the shell. Here again, however, the difficulty can be overcome by gas storage.

The loss of water leading to the increase in the size of the air-space is not very important, as we have said, but it accompanies changes which do constitute deterioration. In parallel with the loss of moisture from the egg through the pores of the shell, there is a movement of water from the white into the yolk. Thus, in eggs which have been stored for any considerable length of time the yolk tends to be 'flabby' or 'runny'. This does not damage the nutritional value of the eggs as food; but it makes them difficult to poach or fry satisfactorily; and for this reason leads to a dislike of stale eggs. The transfer of water from the white to the yolk can be postponed in two ways. The first essential is care on the part of the farmer and good administration on the part of the packing station, so that the fresh egg is got into cold storage at the earliest possible moment. A comparatively short delay at normal air temperature leads to a material reduction of the period during which the yolk resists waterlogging when the egg is in cold storage. The second measure by which the yolks can be preserved is the introduction of carbon dioxide, as aforesaid, into the atmosphere of the store.

The loss of water from the egg and the transfer of water from the white to the yolk are physical effects. Besides these changes, however, chemical reactions take place which equally lead to the undesirable properties of the stale egg. In a fresh egg, the white possesses a certain firmness. During storage a chemical change occurs in the protein which produces 'watery white'. This is responsible for a considerable amount of spoilage under commercial conditions. A similar change which affects the thin protein membrane surrounding the yolk leads to a liability for the yolk to rupture. Apart from the aesthetic deterioration of 'watery whites' and broken yolks, these results of old age in the egg tend to make it more susceptible to the bacterial infection which leads eventually to the full-blown rotten egg. Chemical deterioration, however, can be delayed by refrigerating the eggs as soon as possible, by keeping them at a low temperature throughout their storage life, and by injecting carbon dioxide into the atmosphere of the store. Carbon dioxide is particularly effective in combating one further symptom of staling—the development of an increasing yellowness in the colour of the yolk.

The changes we have so far described are disagreeable and unattractive but they do not render eggs uneatable. It is the effect of bacteria of various sorts that transforms the stale egg into a bad egg. Although bacterial infection of the developing egg within the hen is known to occur, the majority of eggs are bacteriologically sterile when they are laid. But unfortunately the environment into which the egg passes is far from sterile and the average 'clean' eggshell has been found to be covered with from 100,000 to 1,000,000 bacteria and from 200 to 500 mould spores. These numbers are multiplied many fold when the eggshell is dirty. Many of the bacteria on the eggshell are capable of turning the egg rotten if they gain entrance into it, and certain of them, notably members of the *Pseudomonas* group, grow fairly well at freezing point. An egg, the shell of which is much infected with *Pseudomonas*, may therefore become a 'green rot' after about a month even if it is kept in the best controlled cold store.

The defences of an egg against the bacteria that surround it are the natural coating of mucin on the outside of the shell, the relative impermeability of the shell itself, the degree of anti-bacterial acidity in the white, and a group of antibiotic substances in the white which are hostile to invading organisms. Hence a farmer who allows his hens to lay eggs in the dirt, and then has to wash the shells, will get his eggs infected because he is introducing bacteria in the first place and then washing off the protective layer of mucin. Similarly, the hen that lays eggs with particularly porous shells will have them more readily penetrated by micro-organisms. And finally, as eggs become stale, the yolk may break out of its sack. Yolk is a particularly favourable medium for micro-biological multiplication and is, indeed, used by bacteriologists if for their own purposes they wish to encourage the growth of sensitive and discriminating bacteria.

When one starts to review all the different types of microbial infection from which an egg may suffer, it seems remarkable that any at all survive storage unscathed. 'Whiskers' on the shell may be caused by fungus. This does little more than give the egg a musty flavour. An organism called *Sporotrichum* causes the white to form a 'pink rot'; another called *Cladosporium* causes black spots. If either of these penetrate to the yolk, rapid and complete decomposition occurs. The commonest bacterial infection in commerce is due to *Pseudomonas*, which leads to a rather pretty green rot. Later on, however, the egg develops an unpleasant smell of cabbage water. The commonness of this infection is due party to the fact that the organism is widely scattered in soil and in water, and partly to the difficulty of detecting infected eggs by means of the candling lamp. Then there are highly disagreeable 'black rots' due to *Proteus* organisms. These really are rotten eggs; gas sometimes accumulates in them and the egg bursts when the shell is cracked. The smell is particularly offensive. Besides these, the 'musty' eggs infected with *Achromobacter* and the 'fishy' eggs infected by coliform organisms seem comparatively innocuous.

Unquestionably infection by moulds and bacteria is a serious source of loss and anxiety to those responsible for the storage of eggs even under the most up-to-date and scientifically controlled conditions. And the same applies when these conditions of refrigeration and gas storage are maintained during the sea transport of eggs. But, serious though the loss from infection may be and expensive as is the exercise of the necessary precautions and control, the biggest loss of food is usually occasioned by the breakage of eggs due to careless handling at the docks.

Unlike mammalian animals, hens suffer from few infections which can be passed on to their eggs and which can then be pathogenic to man. Almost the only significant group is that of the *Salmonella*, which produces so-called food poisoning. Ducks are comparatively frequent sufferers from *Salmonella* infection and their eggs are a notorious source of infection in man. Hens are occasionally affected, but ill health due to infection derived from hen's eggs was uncommon prior to the development of spray-drying on a large scale.

The *Salmonella* organism is destroyed by heat. Consequently, infected duck's eggs can be rendered safe if they are boiled sufficiently. Heat penetrates an egg slowly. For example, when egg protein reaches a temperature two-thirds of the way to boiling it coagulates. But the fact that an egg boiled for three minutes is still soft in the centre shows that the temperature of the centre has not reached the coagulation point. A five-minute egg, on the other hand, is hard, showing that the heat has in this length of time penetrated all through. In order to render a suspected duck's egg safe, it is recommended that it should be boiled for ten minutes. People who like soft-boiled eggs must take their chance of contracting food 'poisoning' from *Salmonella* infection.

The purpose of drying eggs is to overcome their perishability, to enable them to be stored conveniently, and to reduce their weight and bulk. These objects are not achieved, however, without cost.

In the production of dried egg, the liquid mass obtained from mixing the yolk and the white is pumped through a battery of fine jets. The atomised spray meets a current of warm air which causes the moisture to evaporate and leaves a fine powder of dried egg which falls to the floor of the chamber from whence it is continuously removed to avoid the danger of its overheating. The individual particles are only momentarily heated by this process, and the greater proportion of any bacteria which the original egg contained will remain in the dried powder. The problems involved in the preparation of dried egg are, therefore, in many ways more difficult even than those confronting the people handling and storing shell eggs, each of which is equipped with a series of defences against infection. Moreover, should a single egg succumb to bacterial invasion it will often be eliminated by the candler; and, even if it should be one of the rare specimens containing pathological organisms, its power of doing harm will probably be restricted to one person. On the other hand, a single infected egg added to the mass passing through a spray-drying plant may contaminate a large bulk. Although bacteria will not proliferate in dried egg as long as it remains dry, they remain alive. For this reason it is very important that dried egg should only be reconstituted with water immediately before it is to be used.

Great care is exercised in the commercial production of dried eggs. Pains are taken to use only fresh eggs; care is taken to prevent bacteria from the shell gaining entry to the liquid mass; the general hygiene of the plant and staff is scrupulously inspected; and drying is carried out as quickly as possible. It was found during the war years, 1940–45, that dried egg was a wholesome food; nevertheless it became necessary to issue an official bulletin to emphasise publicly the dangers of dried egg and, more particularly, to point out the necessity of thorough cooking to destroy any harmful organisms. This last warning was found necessary to prevent people using dried egg powder uncooked in such dishes as custard or egg-nog.

In order to produce a tolerably palatable material, egg must not be overheated during drying. If it is, its flavour is impaired and it will not reconstitute properly with water. The moisture content, however, must be reduced low enough, or chemical changes will lead to a different kind of unpleasant flavour; and, finally, the dried egg must not be stored too long or, when it is reconstituted, it will taste like a stale stored egg.

Drying is the form of preservation of eggs which has received the most attention during recent years. The modern, high-quality dried egg is, indeed, a remarkable technical achievement. Its principal drawbacks are that it is all mixed up and, like Humpty Dumpty, cannot be put together again, and that there is often a subtle deterioration in flavour. But it is a substantially wholesome and useful food.

The use of water-glass, a popular and simple domestic method of preserving eggs, is not exploited commercially because it is alleged to take up too much space. Water-glass works by sealing the pores of the shell and thus preventing the evaporation of water and the loss of carbon dioxide. If eggs in water-glass are kept in a cool place, they can safely be preserved for from nine to twelve months. Perhaps the commercial neglect of water-glass eggs is partly due to the grubby appearance of the shells when they are taken out of the preservative. The propensity of water-glass eggs to burst when they are boiled arises from the fact that the shells have become impervious. If they are pricked with a needle they can be boiled without disaster.

As we have already seen, the customary commercial method of preserving eggs is cold storage, either alone or in conjunction with carbon dioxide gas. Cold storage is, however, also applied to eggs designed for use, not by the domestic consumer, but by confectioners and manufacturers. In the days when, for the rich countries of the West, food was a cheap commodity of international trade, liquid egg in tins was imported into the British Isles from China. The imports were unpopular among the indigenous poultry raisers because they undercut the home market, and various forms of attack were launched against them. It was, indeed, suggested that because the hens ate unmentionable Chinese foods, the eggs must be contaminated. Mercifully for many of us who are not eggs, infectious diseases in the offspring are rarely derived from the food of the mother.

Since the end of World War II, liquid egg has again appeared as an article of commerce. In well conducted establishments, liquid egg is manufactured as follows. Accidentally cracked eggs are usually taken. They are broken into a vessel from which they are drawn into a 'heat-exchanger'. This is a machine in which the liquid eggs pass between a series of metal plates while hot water passes simultaneously through the spaces at the other side of the plates. By this means, the egg is quickly heated to a temperature of about 140° F. This is hot enough to pasteurise it but not sufficiently hot to coagulate and hence scramble it. The pasteurisation kills more than 99 per cent of the total number of micro-organisms in the eggs. Liquid egg is usually packed in large tins and kept in cold storage before being used by confectioners and bakers. It is prized primarily for its whipping qualities.

Eggs are a food of very high nutritional value. They provide protein of first-class biological quality and in an eminently digestible form. They are rich in fat and in vitamins A and D. They are one of the best sources of iron in the diet. They are well suited for feeding invalids and children. Yet, during the years when they were scarcest in the diet of Britain and Germany alike, scientists were asked to solve the problem of devising an egg substitute, not in order to fill a nutritional gap but rather to provide the manufacturer with something which would behave like an egg and whip satisfactorily when incorporated in flour confectionery.

As early as 1938 egg albumen substitutes made from fish by a Hamburg firm, the Deutsche Eiweiss Gesellschaft m.b.H., were exported under the title of Weiking Eiweiss. Since that time, with the shortage of real eggs, the product has increased in popularity. This artificial egg white is made from fillets of cod or haddock, from dried salted stockfish or, oddly enough, from shrimps. The fish is shredded, soaked in warm dilute acid and then washed in water. The fat is extracted from it, either with alcohol or with trichlorethylene, which is the fluid commonly used for dry-cleaning clothes. The dried, powdered fish, after having been treated in this way, is finally heated in a solution of caustic soda. When it has become sufficiently broken down, the soda is neutralised with acetic acid and the mixture spray-dried. It is described in a publication prepared by the British Government in 1949 as being of 'good colour' and with a 'slight, readily masked odour'. Weiking Eiweiss, indeed, has been used in place of egg in mayonnaise, 'butter', 'cream', ice cream, aerated bakery products of many kinds and for various technical uses.

We have already discussed the motives which impelled the British authorities to give first priority to milk in their plans for food production in World War II, and at the same time to give a low priority to eggs. It is now interesting to observe, therefore, that when the acute shortage of egg albumen for the manufacture of confectionery made itself apparent by the normal pressure of economics, the Government took a keen interest in the production by technical means of egg albumen substitutes. And second only in popularity to that derived from fish was another manufactured from 'surplus' milk. This was also a German invention controlled originally by a firm in Stuttgart. When designed as a substitute for egg white, the product is called Milei-W, the W standing for *weiss*. Skimmed milk is used as a raw material. Its natural acidity is first neutralised with caustic soda and the volume then reduced to about one-third by evaporating in a vacuum pan. It is then made strongly alkaline with slaked lime and spray-dried. The powder, when mixed in cakes and other foods, has foaming properties similar to those of the white of egg it is designed to simulate.

If one wishes to produce an artificial egg yolk powder, Milei-G can be used. The G on this occasion stands for *gelb*. This material is made by concentrating skimmed milk as before and adding to it a mixture prepared by treating sour milk curd with a mixture of phosphate salts similar to those used in the production of 'processed' cheese. The whole mixture is then made alkaline with caustic soda and carob bean meal is added, followed by acid sodium pyrophosphate to neutralise the acidity. It is then dried on heated rollers. Milei-G was used in Germany mainly for the manufacture of dumplings and batter puddings. It is claimed to possess remarkable water-binding qualities and forms useful emulsions. By suitable modifications in detail—*i.e.*, the omission of carob bean meal and its substitution by a yellow dye, and the inclusion of a proportion of specially fermented whey—a so-called whole egg substitute, Milei-V, the V standing for *vollei*, can be produced.

One further raw material in addition to fish and milk can be manufactured into an egg albumen substitute—slaughter-house blood. The ingenious Germans again initiated this substance, which they called Plenora and used widely in the bakery and grocery trades. It can effectively replace white of egg; it has approximately equivalent whipping qualities and can also be used in place of whole egg yolk in such comestibles as mayonnaise.

The manufacture of Plenora is comparatively simple. Arrangements are made at slaughter-houses for sodium citrate or sodium phosphate to be added to blood while it is still warm. These substances prevent it from coagulating. It can then be filled into drums and sent to the factory. At the factory it is put through a machine working on the same principle as a cream separator. By this means, the plasma, a clear straw-coloured fluid, is separated from the red part of the blood. This plasma is then spray-dried, mixed with a proportion of starch and a little locust kernel gum, and sold to the bakery and grocery trades.

Let us now leave egg substitutes and return again to the egg itself and the hen that produces it. The original jungle fowl laid only twenty or thirty eggs a year. The modern poultry breeder is responsible for the development of a hen capable of laying two hundred and fifty eggs a year. Such a bird will manufacture and pack 31 lb. of finished product although she herself may only weight 4 lb. It is interesting to observe that, far from causing a deterioration in the product, the enormous stimulation of reproductive activity represented by the performance of a modern hen gives an egg with a composition superior to that of the less efficiently bred bird. In many respects, the eggs laid by high-producing hens are better than those laid by low producers. The properties included under the term 'quality' are frequently characteristic of the eggs of individual birds and are influenced mainly by genetic factors.

The secret of the high-producing hen of large good-quality eggs lies in the trap nest. So long as birds were treated as a flock, no consistent improvement in their performance from generation to generation could be achieved. However, as soon as the specialist poultry producer began to study his birds consistently, individually and in detail, he was able to weed out the poor performers and the producers of blemished eggs, and, most important of all, he could breed from the best individuals. The trap nest is a laying box fitted with a shutter so arranged that it drops when the hen steps in to lay her egg. The poultryman must be diligent and go round his boxes at frequent intervals during each day, and he must mark each hen with a numbered ring round her leg so that a record can be kept of each layer's performance.

The selected birds bred by the skilled poultryman can be handled in a number of ways. The most dramatic is the battery system. The hens, under this regime, spend the whole of their reproductive life in a cage which forms one unit in a 'chest of drawers' which is usually three or four tiers high. In the most modern plants, a slowly travelling belt moving under each row of hens continuously removes the droppings, while a food trough moving across the front of the cages allows each bird time to take a 'meal' before the trough passes on. Whenever a bird lays an egg, it rolls out of her cage into a trough prepared to receive it. There is no definite evidence that eggs produced under this system are any less nutritious than those from hens allowed to live a freer life. Indeed, it is hoped before long to be able so completely to perfect the feeding and management of birds in batteries that it will be permissible to use their eggs for hatching.

In the previous chapter we reviewed the evidence upon which it was thought to be most economical to direct the poultry production of Britain away from specialist producers and on to the mixed farms where the birds could eat food and yet, so it was wistfully hoped, deflect no corn from the market. The justification for this policy rested on the thesis that egg production was merely a matter of feeding-stuffs. It was not remembered or not known that mixed farmers rarely trouble to use trap nests.

Over the British specialist poultry farms as a whole, it was estimated that the annual yield of eggs per bird in 1939 was 180, and it was fundamental for commercial success to ensure that a high proportion of these were laid during the winter months. Mixed farms in 1950 were producing perhaps 100 eggs per bird per year, with 60 to 70 per cent. in the spring and summer months. The preponderance of eggs in the 'easy' months of spring and early summer poses a problem to those who wish to provide a steady market for an urban population which has come to assume that every food is in season all the year round. The British Ministry of Food in April, 1949, offered a higher price for eggs produced in autumn and winter; but the concentration of production in the hands of general farmers makes it doubtful whether it will be technically possible to obtain eggs at those times of year when they are difficult to produce.

What then are we to make of the modern trends in food technology so far as they affect the egg as a food? First, it is satisfactory to find that the enormous production of the modern hen tends to improve, rather than to damage, the egg as nutritious food for man. Next, we find that, in advanced countries, when a reasonable state of prosperity exists and no major war is in progress, egg production for the market tends to be in the hands of expert technicians who achieve great skill in processing concentrated feeding-stuffs, many of which may be imported specially for the purpose, into eggs. Under the happy conditions postulated, the modern tendency is for the eggs to be economically produced, carefully graded and marketed according to quality.

Because in the twentieth century it seems to be normal for about one-fifth of the period to be devoted to major wars, the manufacture of eggs from imported feeding-stuffs has been adjudged luxurious and, in order that limited supplies may be distributed to the best advantage and that eggs may travel long distances in an edible condition, much technical effort has been devoted to problems of storage and preservation. How shall we assess the success of the technicians? They can keep an egg in cold storage for a year and, if their work has been efficiently done, it is still a 'fresh' egg at the end of the time. It is true that there are a hundred and one bacterial and chemical enemies lying in wait to convert the egg into a condition varying from 'stale' to down-right 'bad'. But bad eggs were probably commoner in less crowded days before ever the food technologist was heard of.

For eggs as eggs, therefore, modern science has achieved progress. Cracked eggs bulked together, pasteurised and frozen represent a successful utilisation for manufacturing purposes of food which might otherwise go to waste. The views of the intelligent consuming citizen on dried egg may be less unanimous. Dried egg is a useful commodity, which retains the high nutritional value of the original eggs from which it is manufactured. It can be used for cooking in a variety of ways and, if its dietetic quality is not so good as that of fresh egg, it is sufficiently high to escape adverse comment at least in cakes and other mixtures, where it is not unduly exposed to an attentive and discriminating palate. In one respect only is dried egg to be distrusted: it presents a hazard of disseminating *Salmonella* food poisoning. The White Paper, however, which discussed the extent of this danger, concluded that, provided the dried egg was sensibly used and well cooked, the risk could legitimately be taken.

The nutritional value of eggs lies partly in their chemical composition. This shows valuable protein, iron in lavish proportions, vitamin A, vitamin D and numerous members of the vitamin B-complex. But besides this excellence of composition, egg is of nutritional importance because of its technical qualities. These allow cakes and other confectionery to be aerated, bind food together and, above all, impart flavour and quality to numerous dishes.

The ingenious substitutes for egg and for egg albumen do not claim the vitamins, the iron and the rest which eggs themselves contribute to the chemical composition of the diet. They do, however, provide some of the technical qualities which add to the palatability and attractiveness of the diet. Those which we have discussed, composed as they are of fish protein, milk protein and the protein from blood, are nutritionally unexceptional and hence, if they do indeed contribute to the aesthetic properties of the diet, we can but congratulate the technologists who devised them. Nevertheless, underneath our respect for the march of science we may retain a sneaking yearning for an egg preserved merely in its own shell and by the chemical mechanism which it contains in nature.

7

Milk, Cheese, and Ice Cream

THE modern man in the street who talks about 'milk' is referring only to cow's milk. This is a point worth remembering. Furthermore, in discussing the technical treatment of milk today, we shall be compelled to spend a substantial amount of time in considering its nutritional value. It is upon this, and not upon its aesthetic or culinary qualities, that the many efforts to increase milk consumption are based.

Cow's milk is a very remarkable food for man, but it is not quite perfect, nor is cow's milk the only kind of milk there is. For example, at an important scientific meeting held in London in 1947, an enthusiastic transatlantic dietitian was praising the achievements of a particularly up-to-date community where every child had been persuaded to consume an immense annual gallonage of hygienically processed cow's milk. The speech would have been commendable had it been restricted to praise; but when the speaker contrasted the happy state of the one community with the deplorable conditions of another, a certain African territory where statistics of infant milk-drinking showed a smaller *per caput* consumption, a second nutritionist, who was familiar with the denigrated population, pointed out that, although the figures for bottled cow's milk consumption were correct, nevertheless the amount of *human* milk drunk by each infant in the second territory was very much greater than that consumed in the first.

In Victorian slang, milk was called 'sky blue', in poetic reference to the delicate colour of the fluid when diluted with water. One of the first tasks to be tackled by public analysts was the elaboration of reliable analytical methods to enable them to detect the addition of water to milk and to support their conclusions in a court of law. Along with the detection of added water, came the analytical determination of the removal of fat, that is, the discovery whether or not the milk had been partly skimmed. These problems, together with the detection of cruder forms of adulteration, were quickly solved. The principal difficulty in their solution arose from the wide variation which naturally occurs between the milk of one cow and that of another, and between the milk produced by the same cow at different stages in the lactation period or when given different types of feed. The existence of natural variation in composition led to the inclusion of an 'escape clause' in the legal regulations governing standards of milk composition. This clause was the 'appeal to the cow'. Thus, it was valid defence against a charge of adulterating milk for a farmer to produce in his byre a cow which would supply the same low quality of milk as that upon which the prosecution was based.

The outstanding nutritional value of milk is based on three principal scientific facts: it is an exceptionally good source of protein which is of high biological value in the growth of children; it is the best source of calcium in the diet, and thus encourages sound bone and tooth development; and it contains a useful miscellany of vitamins.

The special importance of milk proteins lies in their ability to enhance the biological value of the proteins of such staple vegetable foods as cereals and potatoes. Thus, for example, a combination of bread and cheese (which comprises almost all the protein part of the milk) had, when submitted to a standardised experimental test with laboratory animals, the same biological index of 75·5 as cheese itself, although bread alone had a biological value of only 52·0. Similarly, a combination of milk and potato had a biological value of 86, almost as high as that of milk's 87, in spite of the fact that potato by itself had a value of 71.

The calcium component of milk is important because, as a source of this mineral, milk stands alone. No other food provides a fraction as much and many foods contain substances which actually raise the requirement for calcium without themselves providing any material amount.

Yet, in spite of the true scientific reasons which elevate milk to its predominant nutritional position, the component upon which its quality is popularly judged is fat. People look for creamy milk, and the principal clause in the legal definition of milk is that it shall be a fluid containing not less than 3 per cent. of fat.

Three per cent. of butter fat is actually a modest target; cows from Channel Island breeds produce milk containing 4½ per cent. of fat or more. But the definition having been hallowed by custom and by legal enactment, and the payment of milk being based primarily on gallonage, it is not surprising that farmers have turned their attention to developing a cow that will produce the maximum volume of milk with 3 per cent. of fat in it. The result of this breeding policy has been exceedingly successful, and cows have been produced which yield fantastically large volumes of milk. At the same time, however, the composition of the milk in all those things which matter has steadily deteriorated. The milkman no longer puts water into the milk. To do so would be illegal and, in view of the march of analytical chemistry, it would also be impolitic. The cow puts the water in instead. This is legal and is also an example of the skill shown by the biological scientist in breeding exactly the type of animal the market demands.

The market provides no direct financial inducement to the producer to maintain any standard of *nutritional* quality in the milk he sells, and, as we have seen, he cannot be legally convicted for selling milk of poor quality, no matter how poor it may be, if it is as it came from the cow. There are, as Professor H. D. Kay pointed out in 1950 at the British Association for the Advancement of Science, 'quality' dairy farmers. These men apply modern knowledge to ensure an irreproachable level of quality in the milk they sell. This is done by milk-quality recording and by breeding preferentially from strains giving quality as well as yield; by feeding the cow supplementary rations before the birth of her calf, which usually improves the quality of the milk as well as the yield; by giving the milking cow food in proportion to her yield of milk; and by making use of modern methods of preparing and storing home-produced grassland products so that the composition of the cow's milk in the winter months can be maintained at an adequate nutritional standard. These men exist, although there is little material encouragement for their efforts. But they can enjoy the satisfaction of good craftsmanship and the knowledge that they are providing winter milk upon which a child's diet can depend for an adequate supplement of protein, calcium and vitamin A.

The fact that milk is such an excellent foodstuff makes it a favourite breeding ground for bacteria. Furthermore, as we mentioned in Chapter 3, tuberculosis is a common disease among cows. It is, therefore, as important for producers to maintain good bacterial-quality as it is for them to maintain satisfactory compositional-quality in the milk they sell.

Serious efforts are being made to stamp out bovine tuberculosis in the United Kingdom, although to many who see the ravages of the disease in infected children progress seems slow. For example, in the summer of 1950 an 'area eradication scheme' came into force. This was designed to reduce the number of tubercular cows gradually, so that in, say, fifteen years none would remain. Immediate slaughter of all diseased animals would be inadvisable, attractive though it appears to those impatient to improve the public health, because it would cause a disastrous shortage of milk and a serious disturbance of farm economy; the cow plays an important part in maintaining soil fertility, and some replacement stock must be bred for a while from tuberculin-positive animals. Instead of total eradication throughout the country, selected areas, beginning in the autumn of 1952 with two of the 'cleanest'—in south-west Scotland and in south-west Wales—are to be declared eradication areas. There, it is planned (this is written in 1950) reactors will be slaughtered and compensation paid, and movement of cattle into the areas will be controlled; meanwhile, testing of herds is being offered without charge. In two further areas—the Scilly Isles and the Shetland Islands—all cattle are already attested. But, as was said in Chapter 3, in England only 10 per cent. of the cattle are known *not* to have tuberculosis, in Wales 25 per cent. have *not* got tuberculosis and in Scotland it is known that 33 per cent. have *not* got it. This, of course, though bad enough, does not mean that 90 per cent., 75 per cent. and 67 per cent. in the three countries are infected.

As the eradication scheme develops, the effect on the incidence of pulmonary tuberculosis in man may prove to be unexpectedly striking; studies in Scandinavia have shown that in rural areas as many as half the cases of phthisis may be due to the bovine organism. But clearly the people who are going to be infected with bovine tuberculosis from the milk during the fifteen years of the scheme cannot afford to wait, and there is no need for them to do so. Efficiently conducted pasteurisation of milk renders it safe from the tuberculosis organism and from the other pathogenic bacteria which it may harbour as well. Yet it is one of the painful paradoxes of an otherwise intellectually advanced nation that in Great Britain there has always existed a powerful and well organised group of people opposed to pasteurisation. Some of these people may be swayed by economic motives arising from the expense and trouble of pasteurising milk which they can more conveniently sell unprocessed, but many of them are entirely disinterested and, although perhaps misguided, are influenced by a sincere and deep-seated emotion backed up by a miscellany of *ex parte* arguments.

Uneasiness over the frequency of milk-borne disease, especially tuberculosis, has been felt increasingly ever since the first decade of the century. Rising alarm, after the customary gestation period of a war and a lapse of twenty years or so, led to the appointment in 1932, by the then Prime Minister, of a Committee on Animal Diseases which was made a part of the Economic Advisory Council. This Committee pointed out in 1934 that about 40 per cent. of the cows in the country were infected to a varying degree with tuberculosis, that at least 0.5 per cent. were excreting virulent tubercle bacilli in their milk, and that over 2,500 human deaths occurred annually in Great Britain from tuberculosis of milk-born origin. Among other proposals, the Committee recommended the introduction of some measure of compulsory pasteurisation.

These findings, which had been accepted only after most careful scrutiny of the evidence, could not be ignored, and various steps were taken by the Government. After a three-years delay, a White Paper on Milk Policy was published in July, 1937, in which legislation involving the principle of compulsory pasteurisation was suggested. Pasteurisation, in deference to the known emotional antipathy of the 'anti-pasteurisationists', was put forward diffidently in spite of the evidence of the harm arising from tuberculosis. The White Paper proposed that, subject to certain conditions and exceptions, Local Authorities should be enabled to apply for an Order making compulsory the efficient pasteurisation of milk sold by retail in their areas. Clauses to this effect were included in Part VII of the Milk Industry Bill which was introduced after another year's delay in November, 1938. Though hedged about with many equivocations, they would have gone some way towards providing a safe milk supply. The Bill, however, met with a great deal of vociferous opposition; and so, regardless of the Committee's evidence of disease and death, the Government withdrew it after its first reading.

At the request of Mr. Walter Elliott, a later Minister of Health, Professor G. T. Wilson of the London School of Hygiene and Tropical Medicine prepared a complete review of the effect of pasteurisation on the nutritive value of milk, the extent to which unpasteurised milk was infected and the amount of human disease resulting therefrom, and the effect on the health of a community of substituting pasteurised for unpasteurised milk. In the first part of his monograph, Professor Wilson marshalled all the available evidence as to the effect of pasteurisation on the composition of milk as a food.

The process of pasteurisation, about which so many violent views have been expressed, commonly amounts to the heating of the milk to 145 to 150° F. for half an hour, followed by immediate cooling. This produces a number of minor changes apart from the major effect of destroying harmful bacteria. First, the so-called 'cream line' is reduced by something up to a quarter. This is quite unimportant; indeed, 'homogenised' milk is so treated as to have no 'cream line' at all. Second, about 5 per cent. of one of the milk proteins, lactalbumin, is coagulated; and in milk that has been pasteurised some hours previously, but not in freshly pasteurised milk, the coagulation time with rennet is increased by about one quarter. On the other hand, the resulting clot tends to consist of finer particles and to be of a more open texture than that formed from unpasteurised milk, so that the digestibility of milk for infants is perhaps slightly improved by pasteurisation.

So far as vitamins are concerned, there is a loss of one tenth to one quarter of the vitamin B_1, and an average loss of about 20 per cent. of the vitamin C. This latter is less important than it seems, since the most significant source of loss of vitamin C from milk is exposure to sunlight, and bottles of pasteurised and unpasteurised milk alike are left indiscriminately on door-steps.

The pasteurisation of milk is sometimes claimed to change its flavour. Professor Wilson, therefore, conducted a scientifically designed and statistically controlled experiment. Nine observers were posed with the problem of distinguishing 14 samples of unpasteurised milk from 16 samples of pasteurised milk. On 56 occasions the unpasteurised milk was described by these observers as pasteurised and on 72 occasions the pasteurised milk was described as unpasteurised. Altogether, in 270 observations there were 128 mistakes. If the milk had been sorted entirely at random, without there having been any tasting at all, the statisticians calculated that there would have been only 135 mistakes, or 7 more than there actually were.

The final change occasioned by pasteurisation is that the milk keeps much better.

Against these positive changes may be set a number of negative findings. Thus it is found from feeding experiments on rats and calves that the biological value and digestibility of the proteins are not decreased by pasteurisation, that there is no detectable change in the availability of calcium and phosphorus, that there is no loss of vitamins A and D, and that the total energy value of the milk as a food remains unaltered. The differences between pasteurised and unpasteurised milk are, in fact, far less than those between cow's milk and human milk or even between summer and winter samples of cow's milk.

MILK, CHEESE, ICE CREAM

All kinds of evidence have at one time or another been put forward to show that pasteurisation damages the nutritional quality of milk. Much of this has been of a singularly low evidential value: for example, letters to the newspapers with an account of a farmer who had told the writer of a calf fed on pasteurised milk that died. Considering the small difference in composition between unpasteurised and pasteurised milk, it is not surprising that Professor Wilson, in reviewing the mass of data, concluded that the results of the numerous properly conducted experiments on different species, including children, are in general agreement with each other and fail to show that pasteurisation of milk by the methods most commonly used has any significant effect in lowering its total nutritive value for the growing animal.

Experiments on calves are of particular interest, since they were conducted by six different investigators on a total of two hundred and fifty animals. Although in some experiments the animals on unpasteurised milk grew better than those on pasteurised milk, in other experiments the reverse occurred. Taking all the observations together, the average increase in weight of the calves on unpasteurised milk was 1·23 lb. per day and of the animals on pasteurised milk 1·27 lb. a day. The small advantage of the latter group was not statistically significant, but the advantage, such as it was, was in favour of the calves on pasteurised milk. Incidentally, it was found that adequate pasteurisation of milk known to be tuberculous protected the calves from infection.

A variety of experiments have been carried out to compare the effect of pasteurised and unpasteurised milk on children. The results of all of them have been criticised on statistical or technical grounds, but none of them has shown any difference between the two types of milk. In the United States in 1932, 3,700 children of six years old, some brought up on heated milk and some on unheated milk, were examined. In Lanarkshire, 5,000 children on Grade A Tuberculin Tested milk were compared with 5,000 on pasteurised milk; and, in 1938 and 1939, 8,000 children in Luton, Wolverhampton, Burton-on-Trent, Huddersfield and Renfrewshire were given supplements of biscuits, pasteurised milk or unpasteurised milk. None of these experiments showed any significant difference between pasteurised milk and unpasteurised milk.

Although all this evidence might convince a jury made up of the 'reasonable men' of legal fiction, the true scientific sceptic can always argue that no satisfactory comparison of the effect of pasteurised and unpasteurised milk on human beings has yet been made, since such a test should be conducted on infants receiving an exclusively milk diet.

Let us, then, say that pasteurisation has for all practical purposes no effect on the high nutritional value of milk as a food. It has, however, a very great and well proved effect on milk as a vehicle for the spread of disease. For example, in the United States, the fall in the non-pulmonary tuberculosis death-rate has been considerably greater in towns where the majority of the milk is pasteurised than in towns where a smaller proportion is pasteurised. In Great Britain, the fall in this form of tuberculosis, which (it is known) can be contracted from infected milk, was greatest between 1911 and 1937 in London, where pasteurisation has been most extensively practised, and least in rural areas where little pasteurised milk has been available. In Canada, a careful study of 300 children suffering from non-pulmonary tuberculosis was carried out in 1934, and it was found by bacteriological observations that 15 per cent. of them were infected with the bovine type of tubercle bacillus. All these children were found to come from parts of the country where unpasteurised milk was drunk. In Toronto, however, where compulsory pasteurisation was introduced as long ago as 1915, not a single case of infection with the bovine type was found, in spite of the fact that 26 per cent. of the bulked milk entering the city contained tubercle bacilli before pasteurisation. Similarly, not one case of infection with this type of organism has been encountered in recent years in children born in Paris and brought up on pasteurised or other type of heated milk.

There are several kinds of disease other than tuberculosis which may be transmitted by milk, but the micro-organisms which cause them can also be destroyed by pasteurisation. One of these is undulant fever. In 1938 fifteen patients in Vancouver, clearly diagnosed as suffering from undulant fever, were *all* found to have consumed unpasteurised milk prior to the onset of the illness, in spite of the fact that 78 per cent. of the city's milk was pasteurised. In London, where most of the milk is pasteurised, cases of undulant fever are rare. Of the few indigenous patients, practically all have a history of drinking unpasteurised milk, often 'T.T.' milk. This 'tuberculin tested' milk is derived from cows tested and found free from tuberculosis. These cows, however, are not tested as being free from *Brucella abortus*, the bacteria which causes undulant fever.

Milk-born epidemics of many kinds have been studied at home and abroad and found to be caused exclusively by unpasteurised milk. A serious disease carried by milk is summer diarrhoea in infants. A classic example of the importance of pasteurisation is afforded by the experience of a children's institution in the State of New York, where in 1931 a mortality from summer diarrhoea of 44·36 per cent. was promptly reduced to one of 19·8 per cent. after all the milk was pasteurised, no other hygienic measures having been put into operation.

So effective is pasteurisation in destroying harmful bacteria in milk that it is now the routine public health procedure adopted in outbreaks of milk-born disease. For example, in the large typhoid outbreaks in Bournemouth, Poole and Christchurch in 1936, the medical officer of the Ministry of Health, who was called in to advise on the procedure to be adopted, recommended immediate pasteurisation. He confidently anticipated that no further primary cases of the disease would occur after the expiry of the incubation period. This anticipation was fulfilled. Once the milk supply was rendered safe, an enquiry could be set on foot into the method by which it had become infected.

I have dwelt at some length on pasteurisation. The facts about it put forward by Professor Wilson in 1942, and upon which I have freely drawn, are equally valid in the 1950's when food infections have become increasingly widespread. The reluctance to use pasteurisation reflects an eccentricity of the

British character. Almost alone among civilised nations in not pasteurising all milk, the British are prepared to enjoy the right to be irrational even at the cost of dead and crippled children. During World War II, United States troops stationed in the British Isles were forbidden to drink the unpasteurised milk marketed for the benefit of the indigenous population.

Milk is a very valuable food because of the protein, calcium and vitamins which it contains, but it is not a magic food. Except for the youngest children, it is possible to construct an adequate diet without milk. Possible, but difficult. Or, to put it another way, it is very easy for a diet containing little or no milk to be inadequate for full health, while a diet otherwise badly constructed will often be made 'complete' so long as it contains a reasonable amount of milk.

Two famous experiments are commonly cited to demonstrate this point. In the first, Dr. Corry Mann—who was responsible for the health of a colony of orphans whose diet in 1926, although reasonable according to the orphanage standards of those days, was not lavish—carried out the following trials. The children were divided into seven groups, each containing thirty boys aged 7 to 11 years. They all received the same diet. To the first group nothing was added; 3 oz. of sugar was added each day to the second; ¾ oz. of watercress to the third; 1¾ oz. of margarine to the fourth; ¾ oz. of casein, which is the protein part of milk, to the fifth; 1¾ oz. of butter to the sixth, and a pint of milk to the seventh. At the end of a year the growth of the boys, measured by increase in height and in weight, was greatest in the group receiving milk. Those receiving the butter had also grown more than the others but their gain was less than that of the boys given milk.

At the time it was done, this experiment made an immense impression and it has been constantly quoted ever since. The reason that the results were so striking is that the orphanage diet was deficient in a variety of nutrients, for example, in calcium, vitamin A and in several B-vitamins. Milk contains all of these and consequently the supplementary pint was a convenient portmanteau vehicle for bringing the ration up to an adequate level.

A similar experiment to that of Dr. Corry Mann was carried out four years later, in 1930, by the Department of Health for Scotland when a proportion of the large sample of 17,159 Lanarkshire schoolchildren were given a supplementary ¾ pint of milk a day. Again it was found that the children drinking extra milk grew more rapidly, even during the short four-monthly period the trial comprised, than those who did not have the milk.

It is obvious from all this that milk is a valuable food. The modern technologist has, therefore, given attention to the special problems which arise in distributing a material at once so bulky and so perishable. We have already discussed two technical stages in modern milk control. The first is chemical analysis which, after fifty years of improvement, can detect added water or subtracted cream. Preservatives are forbidden in milk, and the chemist can quickly detect them if they are illegally put in. The second technical step is, of course, pasteurisation. Whether or not the Government or the Local Authority feel scruples about pasteurisation, the big milk combines have no doubt about the necessity for it. We have seen how a single egg from a hen suffering from a *Salmonella* infection may contaminate a thousand others mixed together for conversion into dried egg. Similarly, the milk from a single tubercular cow can infect a thousand gallons of clean milk in a tank waggon. All those who handle and transport a large bulk of milk make sure that it is pasteurised. This not only prevents cross-infection by the germs of tuberculosis, typhoid, septic sore throat, undulant fever, infant diarrhoea and a dozen forms of food poisoning, but it also lengthens the life of the milk as a palatable foodstuff. In fact, it prevents its 'going sour'.

The third technical development in the distribution of milk which has occurred since, say, World War I is the general adoption of centralised bottling. Milk may be produced hygienically from healthy cows, it may be satisfactorily pasteurised and transported aseptically in glass-lined tank waggons, but if it is then dispensed by a careless or ignorant roundsman it may be reinfected. In consequence of this hazard, large sums of money have today been invested in bottling machinery, bottle-manufacturing plant and bottle-washing equipment, and so ubiquitous has the milk bottle become that any comedian is sure of a laugh if he jokes of the town child who is alleged to believe that milk is generated in bottles and not in cows.

The cost of bottles, caps for bottles, bottle collection, cleaning and replacement is a material charge on the cost of milk to the modern industrial community. Alternative types of receptacle have been devised, the most successful of which has probably been the carton which is discarded after use. Up to the present, however, no material improvement on the milk bottle has been achieved in spite of the many serious difficulties which arise from its use.

Milk cannot conveniently be preserved for any length of time as milk. When it is sterilised, which can be done by heating to a higher temperature than that needed for pasteurisation, it keeps well for a considerable length of time but its flavour is markedly altered. Milk is most successfully preserved, other than by the traditional methods of converting it into cheese, by dehydration, that is by removing part or all of the water it contains.

The simplest way of drying milk is probably roller-drying. It is allowed to run in a thin film on to a large heated roller. The film of milk is immediately dried, and is scraped off the roller by a scraper fixed on the opposite side. Considerable skill is required in drying milk by this process. The roller must be hot enough, and the film of milk thin enough, to ensure adequate drying; yet the temperature must not be too high, or the film of milk too thin, lest the quality of the dried product and its nutritional value be affected. Even under the best possible conditions there is some loss of solubility, so that the milk, when reconstituted with water, always contains a proportion of insoluble residue. Nevertheless, when properly made, dried whole milk is a highly nutritious food. This fact was first generally appreciated at about the time of the first Word War, and has since become the basis of an enormous industry devoted to the production of artificial infant foods.

MILK, CHEESE, ICE CREAM

Mrs. Beeton, writing in 1861, describes the difficulty then of rearing an infant 'by hand'. She says:

> When from one or other of the causes already mentioned the mother is unable to nurse her child, and when, as frequently happens, especially among the working classes and the poor, the services of a wet nurse cannot be had, nothing remains but to bring up the child artificially, or 'by hand', as it is called. This is the most difficult kind of bringing up to accomplish satisfactorily, and many more hand-fed children die than those brought up at the breast. There are three kinds of milk, any one of which may serve as a substitute for breast milk. These are, the milk of the ass, the goat and the cow, in the order given.

There were no reputable proprietary infant foods at the time Mrs. Beeton wrote, and even in the second decade of the twentieth century some of those at that time on the market gave unsatisfactory results and did harm to the babies receiving them. Since then, however, roller-dried milk has become recognised as a suitable infant food, and today all the proprietary foods on the market consist almost entirely of it. During World War II, the social services were widely extended and the Government marketed its own 'national dried milk'. It, like most of the advertised products of the independent manufacturers, was composed of roller-dried milk. The Government attempted to be fair to the business interests of the manufacturers and refrained from advertising its own product in competition; nevertheless, in framing regulations for the allocation of milk for infant food manufacture, it could not forbear from lumping them all together under the illuminating and poetic description of PIMF—a word constructed from the initial letters of the words 'proprietary infant milk food'!

The nutritional excellence of roller-dried milk, usually fortified by the addition of synthetic vitamin D as a prophylactic against rickets, and sometimes by iron as well to prevent anaemia, is shown by the fact that, by 1950, the majority of the infants in Great Britain were reared upon it without the dangers and difficulties existing at the time of Mrs. Beeton.

In the medical profession, many leading paediatricians believe that breast-feeding is preferable to the artificial feeding of infants. The scientific evidence on this point, however, is by no means unequivocal, and large numbers of babies, fed artificially, grow up to be healthy children and adults. Above all, the social pressure of the industrial age is set strongly against breast feeding: houses are too small, extra-mural entertainments are too alluring and readily available, and the Government itself, constantly reiterating its belief that factory production is the prime object of human life (at least for the immediate decade), makes artificial feeding seem more convenient and natural. The production of dried milk is, therefore, a useful development of food manufacture.

A second method of drying, by which a product superior even to roller-dried milk can be produced, is spray-drying. This, as we have already seen, is also used in drying eggs. The milk is injected in a fine spray into a chamber through which a stream of hot air is blown. The droplets of milk are immediately dried and fall as powder to the bottom of the apparatus. Spray-dried milk, efficiently manufactured, does not suffer from the partial insolubility which is the principal weakness of roller-dried milk. As spray-dried milk has a slightly higher nutritional value than roller-dried milk it is something of a paradox that the manufacturers of infant-foods, including the Government, prefer the latter. The reason is that spray-dried milk is bulkier, and its use would increase the relative cost of the tins used for packing.

Dried whole milk is useful in many circumstances other than for infant feeding. In certain parts of Australia, for example, it is used in place of fresh milk and is not much more expensive. Its keeping properties, though very much better than those of fresh milk, does not allow its being stored indefinitely. The absence of more than a trace of moisture prevents the growth of bacteria which could bring about decay or putrefication; but, in the presence of air, the fat in dried whole milk undergoes a reaction leading to rancidity. It is customary, therefore, to pack dried whole milk in tins in an atmosphere of an inert gas, such as nitrogen. Under these circumstances it can be kept satisfactorily for prolonged periods of several months. But although rendered substantially stable, a slight fall in nutritional value occurs if the dried milk is kept too long. This is due to a reaction between the protein and the natural milk sugar, lactose.

The fat is skimmed off much of the cows' milk produced in Scandinavia, Australia, New Zealand, Canada and the United States, and is converted into butter. The protein, calcium and the B-vitamins, which are three of the important groups of nutrients to which milk owes its predominant position as a food, remain behind in the skimmed milk. Usually, this skimmed milk is fed to pigs. It can, however, be dried. When it is, it forms a food very rich in protein (because the fat component is no longer present). Though highly nutritious, this dried skimmed milk is not very exciting as an article of diet. For example, because it turns only into skimmed milk when it is reconstituted, it is unsatisfactory in tea. It has, however, many virtues, culinary as well as nutritional, when employed in cooking.

For infants, skimmed milk is less satisfactory than whole milk, because its fat has been removed and its energy value is less. The removal of the fat also removes the vitamin A and vitamin D of the original milk. During World War II, when the British Government wisely imported large quantities of dried skimmed milk into the country under the title of 'household milk', they labelled it, somewhat alarmingly, as 'not to be given to infants'. This referred, not to any harmful property, but to its relative inferiority to whole milk. Nevertheless, the use of skimmed milk is to be recommended as an ingredient in many of the puddings and mixtures given to young children.

The preservation of milk by removing part, as distinct from all, of the water it contains has been practised for a long time. In this process, the milk is evaporated in a partial vacuum until it is reduced to approximately one-third of its original volume. Several varieties of milk 'condensed' in this manner are on the market. Whole milk, condensed and sweetened with sugar, becomes 'full cream, sweetened condensed milk'. The stability of condensed milk depends entirely on the fact that it is sterilised and then canned. It is the canning that prevents infection and deterioration in the milk, just as it would in canned salmon or corned beef. In the sweetened condensed milk, however, the high concentration of sugar has a preservative action, in the same way as it has in jam. Thus, when a tin of sweetened condensed milk is opened, it can be kept for a reasonable length of time. The abuse of the term 'reasonable', however, often makes the comparative stability of the milk a sham—if the opened tin is allowed to stand about under dirty and infected conditions. In these circumstances, the condensed milk may become dangerous to health.

Unsweetened condensed milk will keep no longer than fresh milk once its tin is opened. As anyone who has been in the British military services will know, unsweetened condensed milk, when reconstituted with water, becomes the equivalent of fresh milk in physical and chemical behaviour and in nutritional value, in fact in every respect other than taste. This material is often called 'evaporated milk'.

The third type of condensed milk is that manufactured from skimmed milk. It is in every way equivalent in usefulness to the dried skimmed milk we have previously discussed. Since there is nothing to prevent it, this type of condensed milk also begins to 'go bad' as soon as the tin is opened and micro-organisms from the atmosphere consequently gain admittance.

There has been a long and fluctuating battle among the nutritional scientists as to whether condensed milk is to be praised or condemned as a food. So far as adults are concerned, the battle has passed them by; they have been allowed to fend for themselves and judge the case entirely on its aesthetic merits. But the value of condensed milk for children has been hotly contested. A number of the earlier paediatricians strongly opposed the use of condensed milk for children. This opposition arose from two causes. Firstly, some of the doctors were ignorant of its composition and, secondly, many were opposed altogether to artificial methods of baby feeding. Fifty years ago there was justification for this opposition in view of the risk of food infection being transmitted to the baby from dirty feeding bottles and infected milk mixtures. Today, although some objections are still raised, and for the same reason, it is generally recognised that, provided it is wisely used, condensed milk is as useful for infant feeding as dried milk.

Full-cream unsweetened condensed milk—that is, the so-called 'evaporated milk'—is, when it is reconstituted, nutritionally equivalent to fresh milk in every respect but one. Fresh milk contains a small amount of vitamin C. This is easily destroyed by heating or lost by exposure of the milk to sunlight, but some of it usually survives. Evaporated milk contains almost none, so that it is important for babies fed on it to be given orange juice or some other supplementary source of vitamin C at an early age. To balance this minor disadvantage of evaporated milk, however, it possesses two advantages. Firstly, it is always pasteurised and, secondly, it is frequently enriched with vitamin D, the rickets-preventive vitamin.

Harm occasioned by the use of sweetened condensed milk and condensed skimmed milk has been due, not to any lack of wholesomeness in the products, but to ignorance of their composition. Obviously, a baby must not be fed solely on sweetened condensed milk, or it will get too much sugar. Equally, a baby fed solely on condensed skimmed milk will obtain too little fat and, unless it is given cod-liver oil, too little of the vitamins A and D which are normally found in the butter-fat of milk.

A modern use of preserved milk (usually dried milk in this instance) is for the manufacture of ice cream. Ice cream, like condensed milk, has been a subject of contention among paediatricians. In the United States, where an ample national food supply makes high quality easier, much ice cream is, as its name implies, largely composed of a milk mixture which is to a degree equivalent to a sweetened condensed milk. This type of material makes a useful nutritional contribution to a child's diet. In Britain, however, a strong market demand at a time of food scarcity has given rise to much technical ingenuity in the construction of an article which in taste, appearance and consistency shall be as like what the public remembers good ice cream to be as may be.

Politics is the art of the possible and the British Government in 1949 came to the conclusion that, in the current scarcity of desirable ingredients, it was not practicable to enforce generally a proper standard of quality for ice cream; nor was it, they thought, desirable to restrict total supplies by trying to do so. It, therefore, followed that, so long as it was not actively harmful, any frozen mixture could be marketed as ice cream and left to find its own market. Three forces, of differing power, came to bear on the nature of the ice cream sold in Britain in 1950. First, there was the opinion expressed by the Food Standards Committee of the Ministry of Food that 'a standard was, in principle, desirable'. This committee hinted at a (temporary) standard of 5 per cent. fat, 10 per cent. sugar and 7½ per cent. milk-solids other than fat, and hoped one day to be able to insist that ice cream should be a dairy product principally derived from milk. The second force moulding the nature of ice cream was the available supply of ingredients and the ingenuity of the food chemist. But the most powerful influence towards good quality was keen competition among the manufacturers.

The sort of mixtures used commercially were, say, 40 per cent. full-cream dried milk, 40 per cent. sweetened fat, 10 per cent. soya flour, 5 per cent. sugar and about 1 per cent. each of what were known euphemistically in the industry as 'food additives'—for example, glyceryl monostearate and sodium alginate. Alternatively, a combination of 35 per cent. sugar could be employed, plus, say one-tenth per cent. agar. Fat being an expensive and scarce article, it might be whittled down to 7 or 8 per cent., and its absence partly concealed by doubling the quantity of agar.

Besides the more esoteric substances such as glyceryl monostearate, sodium alginate, agar or gum tragacanth, more mundane ingredients were often put into ice cream. Among these were cereal commodities, notably wheat flour and oat flour. Indeed, custard powders of an entirely cereal composition were occasionally found frozen on the market. Fats of all sorts appeared, even including 'tasteless and odourless' herring oil; and dried milk of all grades, full-cream and skimmed, roller dried or spray dried.

The 'food additives', though used in small amount, are, like flour 'improvers', of technical importance and of great general interest. Sodium alginate and agar can be soon disposed of. They are similar compounds and are derived from seaweed. They possess the property, when dissolved in water, of being able to form a jelly. The principal use of agar has been to jellify the media used by bacteriologists in the technical process they use in isolating micro-organisms. Before World War II, almost all the world's supply of agar came from Japan, and the cessation of supplies due to the fighting promised to raise acute difficulties for the numerous medical and industrial laboratories where bacteriological work was done. The threat was met in Britain in a characteristic way by mobilising volunteer algologists to go to likely places along the sea side to look for suitable varieties of seaweed. So successful were their efforts that, within a few years, so much agar and alginate was available that difficulties were being met in using it all. So far as is known, agar is entirely inert when eaten by human beings; indeed this characteristic has been taken advantage of in the employment of agar as the basis of a popular laxative. It is used in ice cream for its jellying power.

Gum tragacanth is one of a series of natural gums which have been used for a very long time. They delay the separation of oil from water when the two are mixed together. This property is clearly useful in maintaining a homogeneous consistency throughout an ice-cream mixture. Glyceryl monostearate is a comparatively new substance and its employment in the food industry has been viewed with a certain element of thoughtfulness. Its development is closely related to progress in the field of soapless detergents.

Soap washes clean because it is a compound composed, on the one hand, of caustic soda which is highly soluble in water and, on the other hand, of fat which, of course, is miscible with other fats. Thus, the fatty end of the soap molecule attaches itself to the grease in anything being washed and the soda end of the molecule drags it into the washing water. When the shortage of fats caused the chemists to start research to find a substitute for soap, their efforts were devoted to attempts to elaborate molecules, one end of which should be hydrophyllic and the other end lipophyllic. A great many groups of compounds were found with these dual properties of fat-and-water-attraction. Among these were sulphonated fatty acids, compounds of glycerine and fatty acids, of which glyceryl monostearate is one, and a group of compounds in which a curious synthetic substance, partly fat-like and partly water-soluble, called polyoxyethylene, is linked through a sugar radicle with a fatty acid. The most widely used of these last substances has in the United States of America been designated by its initials—POEMS—or poly-oxy-ethylene-mono-stearate.

Polyoxyethylene monostearate has many useful technical properties and seemed at one time likely to become helpful to the food industry. Unfortunately, doubts were felt as to its harmlessness as an ingredient in foodstuffs, and its use for this purpose was prohibited in the United States. Food manufacturers in Great Britain had hesitated to use it from the beginning, and it had never been employed by the more reputable firms. Glyceryl monostearate possesses similar technical properties to those of polyoxyethylene stearate. It makes mixtures of fats and non-fats, of which ice cream is one, more homogeneous and delays the breakdown of this homogeneity.

No definite harm to the health of a specific individual has ever been attributed to the consumption of polyoxyethylene monostearate, but its chemical composition and its 'unnaturalness' gave rise to such doubt that it was considered judicious to sacrifice the valuable technical contribution it was capable of making and deny its use in food. Similarly, no one has ever been shown to have come to harm from eating glyceryl monostearate. But, in this instance, the chemical composition of this new substance is not 'unnatural'. Natural fats are chemically constructed of a unit of glycerol, which is the technical name for the substance popularly called glycerine. Glycerol is a substance possessing three points of attachment. In natural fats, all three are attached to fatty acid units which are sometimes the same and sometimes different. One of these fatty acids may be stearic acid and, in consequence, glyceryl tristearate can be considered to be a natural fat. Glyceryl monostearate, that is to say, glycerol with only one of its points of attachment occupied, does not normally occur in foodstuffs but is possibly one of the degradation products formed in the breakdown of fat during the course of digestion. Hence its use in food, unlike that of polyoxyethylene monostearate, cannot be expected to be harmful.

Modern British ice cream, therefore, is in general, a wholesome food; but its nutritional value may vary very greatly in proportion with, firstly, the amount of dried milk it contains and whether the dried milk is from full-cream milk or from skimmed milk. Secondly, it may contain much or little fat. If ice cream is poor in milk and poor in fat, it must contain some other ingredient. This other ingredient may be flour or another cereal product, in which case the nutritional value of the ice cream will more closely resemble custard-powder custard than ice-cream (using the name literally). On the other hand, the alternative ingredient may be water. If it is, the ice cream will gradually sink below the category of a food, and will have to take its place among such dietetic anomalies as jelly, of which a plateful only contains a pinch of solid matter.

Perhaps by the time these words appear in print a minimum standard of composition may have been fixed for ice cream and it will have assumed the status of a dairy product. Even so far back as 1948, a Government Order, called the Ice Cream (Heat Treatment, etc.) Amendment Regulations, had ruled that all ice cream mixtures should be pasteurised before being frozen. Thus, even though the absence of a standard of composition and the development of clever 'food additives', which enables technical 'quality' to be achieved even in the absence of desirable ingredients, allows some scope for hankey-pankey in the manufacture of 'hokey-pokey', at least the likelihood of microbiological infection and food poisoning being spread by ice cream has been reduced to a minimum.

There is one remaining important product manufactured from milk which we have not yet discussed—cheese. (We shall postpone butter until the next chapter.) To the chemist, the manufacture of cheese consists of coagulating the protein of the milk, not by heat as is done for the protein of egg-white when an egg is hard-boiled, but by the use of acid. This acid is normally formed by the milk-souring bacteria used in cheese-making. When the protein coagulates it drags down the milk-fat with it and, in most varieties of cheese, the calcium as well. Consequently, cheese represents a method of preserving the major nutrients of milk in a quasi-durable form. This, then, is what the chemist sees in cheese.

The nutritional scientist sees a foodstuff richer than meat in animal protein and in fat. That is why at one stage during World War II, when the meat ration was small and the cheese ration large, the then Ministry of Food spent considerable sums of money on advertising to convince a sceptical public that cheese could take the place of meat.

The man with the educated palate does not believe either the chemist or the nutritionist. He is not interested in the preservation of milk nor is he interested (as one day, when the subsistence level is really reached, he may be) in animal protein, fat or calcium. He merely bewails the fact that good cheese is scarce and expensive and that all that the ration provides is 'mousetrap'. But the chemist wins in the end. In spite of the feelings of the gourmet or the regrets of the cheese connoisseur, the reason for the existence of cheese is that it is a traditional method of preserving milk.

When someone blames World War II or the modern, materialistic Ministry of Food for the disappearance of the native British cheeses, he is wrong. British cheese production has been steadily falling for many years, and this is due almost entirely to modern developments in the production and distribution of liquid milk. The development of a stable and increasing all-the-year-round market for milk has undermined cheese-making traditions; it has also contributed towards a decline in pig-keeping and ham and bacon production. In the days when cows were allowed to calve 'naturally' in the spring, just when the first grass was coming along, there was a seasonal flush of milk, much of which would have gone to waste if it had not been turned into cheese on the farm. In the winter the cheese-making dairy farms went into hibernation. In other words, the various local varieties of cheese were fundamentally the preservation products of seasonal milk production. Today, foods 'in season' have been abolished. In the modern world, we expect all foods always to be 'in season'.

The economic weakness of the seasonal production of cheese was the wastage of labour it involved. It was possible so long as the farm worker considered himself engaged by the year; but as soon as he thought of himself as working by the hour, it became impossible. Between the wars, in Britain, a federation of cheesemakers managed to keep things going, but when World War II brought about a scarcity of rural labour the craft of cheese-making collapsed and died.

Modern nutritional policy calls for a steady production of liquid milk, so that priority rations for mothers and babies can be issued regularly and free milk for schoolchildren always be on tap. The school holidays, somewhat anomalously, leave three spurts of milk a year available to the manufacturers of dried and condensed milk and to the cheese factories; but they do not fit in very well with a farm cheese-making programme. Moreover, since the withdrawal of school milk from the children during their holidays is a nutritional paradox based solely on administrative expediency, it is probable that a way will eventually be found to distribute milk to them throughout the year.

In France and Italy, where the official nutritional policy is less systematic than in Britain, the craft of cheese-making (as distinct from cheese manufacture) has survived. Thus in Britain the decision has been taken that the gastronome should forego his former pleasures for the sake of large-scale organisation and mass nutrition. However tempting it may be for the individual to deplore this state of affairs, he must remember that milk has become, because of its exceptional composition, a universal foodstuff, especially for the younger generation. Whoever laments the disappearance of native cheeses must ask himself whether he would truly have it otherwise.

Cheese for general consumption, whether manufactured in

Britain or imported from abroad, is now considered as a vehicle for protein, fat, calcium and the rest and, since a ration must, if social justice is to be maintained, be equally acceptable to the whole population, the rationed cheese must not possess too pronounced a flavour. Stilton and Gorgonzola are ruled out on both counts; the amount of uneatable rind represents an excessive degree of wastage and the strong flavour is not to everyone's taste. 'Cheddar type', on the other hand, gives rise to the least amount of wastage and can best be manufactured with a standard flavour.

The ultimate lowest common denominator is, perhaps, represented by 'process' cheese. This is made by mincing up cheeses and mixing them together into a standard blend. One of the emulsifying agents we have already discussed is then added, and the whole mass heated to pasteurise it and thus prevent any further change. Part of the change would be ripening but part might be a deterioration and the development of off-flavours. The manufacturer, therefore, makes the best mixture he can and then tries to prevent *all* further change. Colouring matter may finally be added, and the cheese passed through a mechanical packer in which it is pressed into small portions, automatically wrapped in tin foil and packed into boxes.

In planning the national nutrition policy and developing the food supply plans through which that policy was to be achieved, the British Government have given a central position to milk. This fact has influenced the technical developments which have taken place. Firstly, we must recognise that the clamant demand for *quantity* has had its effect on the choice of the type of cow and this has affected, and affected for the worse, the quality of the milk produced. Next, the public attention given to milk may have played a part in the political paradox that has left much milk—and, worst of all, the milk produced by the less well equipped purveyors—unpasteurised. It is mainly the big, well organised cities and the big, well organised producers who take advantage of the technical process of pasteurisation by which their milk can be rendered at once safer and more durable. And finally, the emphasis on whole milk as a beverage, whether fresh, condensed or dried, whether for the adult population, the schoolchildren or the infants, has led to a production planned for all the year round, and this, in its turn, has led to the decline in the production of cheeses on the farm.

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Fats and Margarine

An almost mystic significance is attached to fat. The consumption of fat is a sign of wealth; the amount of fat eaten can, within limits and excluding such eccentric people as Eskimos, be used in civilised communities as a measure of the standard of living. Yet, curiously enough, once a very low level of physiological requirements has been surpassed, there is no absolute nutritional need for fat, and many efficient and righteous peoples consume very little. Fat is the most concentrated source of energy of all ingredients of the diet, and it is, therefore, useful in enabling heavy workers to obtain their calories without the necessity for eating a very bulky diet. The 3,500 calories a working man requires to keep him going for a day could be supplied by about 14 oz. of fat. This is the absolute minimum in bulk from which the day's needs could be met and explains why a diet could never be constructed from 'pills' alone. In fact, the maximum proportion of fat calories which a balanced diet can contain is about 40 per cent. so that the most concentrated workable diet possible must be considerably bulkier than 14 oz. But the demand for fats among the predominantly sedentary populations of the modern world is not solely based on its calorific compactness but on its dietetic attractiveness.

Dietary fat is obtained in two forms—'visible' fats such as butter, margarine, lard or olive oil, and 'invisible' fats, including the fat in meat, the oil in herrings or the cream in milk. The proportion of fat which people eat is influenced by custom. In 1947, when the British citizen felt that his fat supply was so intolerably low that he needs must spend a great deal of money in an attempt to produce more from ground-nuts in Africa, the average consumption was 111 grams a head daily. In 1938, it had been 130 grams. Yet Japanese workers at one time only obtained about 20 grams and Roumanians 50 grams.

Nevertheless, in spite of the fact that the nutritionist can easily design a balanced diet containing only comparatively small amounts of fat, the fact remains that people *like* fat; it is essential for civilised cooking and, in consequence, there is a powerful economic demand for it. Furthermore, it is easier for the nutritionist to design a satisfactory diet with a good supply of fat than without it.

The production of fat is today an enormous industry. All but 10 per cent. of the 'visible' fat consumed in Britian before World War II was imported, and the fats available on the markets of the world were, in order of the quantities available, (1) coconut oil, ground nut oil, whale oil and palm oil; (2) butter, soya bean oil, lard and suet; and (3) in quantities less than a fifth of group (1), came cottonseed oil, olive oil and fish oil.

How do the food technologists make use of these diverse fats and turn them all into one of two standard products, margarine or cooking fat? Fats differ from each other primarily in their melting points. That is to say, some fats—for example, olive oil and ground-nut oil—are liquid in a temperate climate, while others, such as lard or suet, are solid. These physical differences are a reflection of underlying chemical differences. As was briefly mentioned in the last chapter, the chemical structure of fat consists of a unit of glycerol to which is attached three units of 'fatty acids'. These three fatty acids may be the same but they are usually different. Fatty acids as a group are constructed of a chain of carbon atoms linked in line and terminated by an acid radicle. They are always made up of chains containing an even number of carbon atoms. The two spare points of attachment of most of the carbon atoms in a fatty acid (carbon possess four linkage points and two will be occupied in forming the chain) each carry an atom of hydrogen. In some fatty acids, however, certain of the carbon atoms may be joined by a double linkage and will, in consequence, only carry one hydrogen atom. These 'unsaturated' fatty acids have a lower melting point than those which are fully saturated. The fats containing them, will therefore, be more liquid at normal temperatures.

It is this fact which enables the chemist to change at will the character of the fats and oils coming into his hands. By a process of 'hydrogenation' he can introduce hydrogen into the vacant spaces in the fatty acid chains, and thus raise the melting point. He can consequently 'harden' an oil, such as ground-nut oil, for example, until it becomes as stiff as lard. The extent to which hydrogenation is carried governs the hardness of the resulting fat. Margarine intended for the tropics is consequently manufactured with a higher melting point than margarine made for consumption in Great Britain.

The first important technical procedure used in the modern manufacture of fat is this process of hydrogenation, by which any consistency of fat can, within reason, be produced, no matter what starting material is available. So long as the hardening process is not pursued so far that the resulting melting point is substantially higher than 98·4° F., the body temperature, the absorbability of the fat remains the same and its property of providing calories for the body is unimpaired.

The second new process applied to fat manufacture is entirely concerned with its nutritional value. This point is worthy of emphasis. Many technical processes in food manufacture have as their object, as we have seen, the attainment of some technical advantage or the development of some real or assumed aesthetic improvement.

Lard is the most popular cooking fat in Western societies of the temperate zones. Consequently, cooking fats manufactured from hydrogenated ingredients are commonly designed to simulate lard as closely as possible. Lard is merely fat; it contains no vitamins or supplementary nutritional factors. On the other hand, butter is one of the more important of the protective foods and contains material amounts of vitamin A and vitamin D. Thus when margarine was first invented, a legitimate criticism of its food value was that it did not possess these vitamins and could not, therefore, exert the protective action of butter. The leading manufacturers of margarine quickly bestirred themselves to remedy this defect.

Vitamin D occurs in cod-liver oil. It is soluble in the oil but it is not an oil itself. Before long a way was found to extract it from the fatty part of the oil. Although this was in its way a signal achievement, it was not of much help to the margarine manufacturers because it was quickly discovered that the concentrated vitamin D extracted from cod-liver oil gave the margarine a fishy flavour. The removal of this fishy taste was never achieved but the problem was solved by an entirely new discovery—the observation, published in 1927, that vitamin D could be produced by the irradiation of ergosterol, a substance first isolated in France in 1871 by a chemist called Braconnot who obtained it from a fungus found on rye.

But no sooner was the problem of vitamin D solved than it was discovered that the provision of a technically acceptable source of vitamin A presented equal difficulty. Vitamin A is associated with vitamin D in cod-liver oil and it was also found to occur, and in substantially greater concentrations, in the liver-oil from other fishes. Finally, the margarine manufacturers found that vitamin A-concentrates from the liver of the 'soup-fin' shark—could, with suitable technical precautions, be added to margarine without any fishy flavour being apparent. Arising from this discovery, a new industry was established to exploit the use of soup-fin shark and other fish which were also found to concentrate vitamin A in their livers. Margarine could then take its place, so far as vitamin A and vitamin D were concerned, as equal nutritionally to summer butter and much richer than British butter manufactured in the winter. This technical achievement must rank as the second major new process applied to fat manufacture.

At this point, we ought, perhaps to pause to review the available evidence bearing on the question: is margarine as good as butter? Let us deal first with the nutritional aspects.

Margarine was invented in 1870 by an ingenious Frenchman called Mèges-Mouriès. It was originally made by melting down and clarifying various animal fats, that of the ox being chiefly employed. These fats were at first churned with a proportion of cream in order to simulate as closely as possible the making of butter. Today, margarine is a manufactured imitation of butter made by mixing whale oil and vegetable oils hydrogenated to the appropriate degree with lecithin or some other stabiliser, an oil-soluble dye and a proportion of soured skimmed milk to supply flavour.

Since the time of its invention, margarine has had to face several violent attacks, most of which have been based on the allegation that its nutritional value is inferior to that of butter. We have already seen that, so far as vitamins A and D are concerned, margarine is equal to good summer butter and better than the butter made from the milk of stall-fed cows. Nevertheless, the attacks have not ceased. In the United States they derive from the commercial hostility of a powerful dairy industry. Through the pressure of this industry a law is in existence in America forbidding the addition of colouring matter. Illogically but understandably the lard-coloured margarine resulting is not widely popular.

Yet, prejudice apart, there is cause to review the relative nutritional values of margarine and butter in the light of a number of scientific facts now available. Although the appearance and taste of modern margarine and butter are not dissimilar, the chemical nature of the fats composing them is different. For example, butter is remarkable in containing *butyric acid*, a fatty acid with only four carbon atoms in its chain. Extensive studies have, therefore, been carried out to determine whether butter-fat is more easily absorbed than the fats in margarine. In a long series of experiments in America it was found that the individual fatty acids composing butter and those composing margarine were equally well absorbed. Many of these investigations were done on rats. In other trials, experimental men and women were given more than 8 oz. of margarine fat daily. The absorption was found to range from 94 to 99 per cent. for different individuals, with an average of 97 per cent. A second group of people given butter absorbed from 92 to 100 per cent. of it. The average was again 97 per cent.

Accepting the equal degree of absorption of the two types of fats, certain Dutch scientists believed that they had discovered evidence to show that summer butter caused slightly greater growth in rats than that achieved by margarine. This observation was closely studied by workers in America, Great Britain and in Sweden, but none of them were able to substantitate the Dutch findings. Besides rats, calves were also used as experimental animals, and finally a group of dauntless U.S. nutritionists organised a trial with 255 children. The feeding tests continued for from 6 to 24 months, but no significant difference in growth or health could be detected between the 125 children given butter and the 130 receiving margarine.

The conclusions thus briefly summarised have not been reached without a good deal of polemical argument among the scientists themselves. Most of the divergent results which have been obtained—indicating that butter was better nutritionally than margarine—have since been attributed to the fact that the butter was more palatable than the margarine, and that the experimental animals consequently ate more of it and therefore grew more. When *diacetyl*, *butyric acid* and *monobutyrin*—substances present in butter, which give it its characteristic taste—were added to other fats, including lard and tallow as well as margarine, results equal to those with butter were obtained. This, then, appears to be the important point. If the manufacturer possesses sufficient skill to colour and flavour his fats so that they look and taste like butter, and if he also adds vitamin A and vitamin D in the amounts in which they occur in butter, there seems no evidence to show that margarine is in any respect inferior to butter as a food. British margarine manufacturers add the necessary vitamins to their product but not all of them achieve a perfect reproduction of butter's taste, smell and consistency.

The development of margarine has enabled civilised communities to utilise for food a wide variety of fats and oils which might otherwise have proved distasteful and unpalatable. Margarine enables vegetable fat to fill the place of animal fat, and vegetable products are always more economical to produce than animal products. The supply of vegetable fats, however, has not proved to be inexhaustable and efforts have, therefore, been made to synthesise fat from non-food sources.

Experimentally, fat has been synthesised from petrol and from coal. Petrol is composed chemically of a mixture of 'hydrocarbon' chains. These hydrocarbons are carbon atoms linked on to each other and with all the free linkages not employed in holding the chain together occupied with hydrogen atoms. Unlike the fatty acid chains of edible oils, the hydrocarbon chains of mineral oils are not capable of being attached to glycerine and they contain no oxygen. Most of the work aimed at synthesising edible fat from mineral oil has been done in Germany. During the 1939–45 war, a fraction formed during the hydrogenation of coal and its conversion into petrol was used as the starting material for fat synthesis. The chemical problem was to add oxygen to this 'hydrocarbon'. The material was, therefore, mixed with permanganate and heated to about the boiling point of water. Air was then bubbled through for twenty-four hours. At the end of this time about one-third of the petrol was converted to fatty acids. These fatty acids can be separated from the mineral oil by being converted into soap through the action of caustic soda. The soap settles out, the fatty acids are released again by the action of sulphuric acid and are finally linked on to glycerine by being heated with it in a vacuum vessel.

The resulting synthetic fat has two peculiarities, one of which is of great scientific and nutritional interest. The second peculiarity is a practical one. We have already seen that natural fats are composed chemically of a glycerine molecule attached to three fatty acids. The fatty acids in natural fats always contain an even number of carbon atoms. With synthetic fats, however, the fatty acids contain even and odd numbers of carbon atoms indiscriminately. A further difference in synthetic fats is that some of the fatty acids in them possess 'branched' chains. German experiments with large numbers of rats, mice, guinea-pigs, rabbits and dogs convinced the people who carried them out that synthetic fat behaves like natural fat in the processes of absorption, assimilation and utilisation, and that it causes no marked changes in the organs of animals fed on it. In trials on human beings, however, it has been found that the consumption of synthetic fats causes an increase in the amount of certain unusual acids in the urine. Thus, although margarine made with a proportion of synthetic fat has been manufactured, some doubt is still felt in medical circles as to the possibility of undesirable effects resulting from its consumption.

The presence of fatty acids with an even number of carbon atoms and with branched chains is the *chemical* peculiarity attaching to synthetic fat. The *practical* peculiarity is that it is very, very difficult indeed to free it from the flavour of petrol! Scientifically, perhaps, this is a trifling matter, but a better example of damning with faint praise could hardly be found than the comment on margarine made from synthetic fat which was printed in the British Government document on the German food manufacturing industry issued by His Majesty's Stationery Office in 1948. It runs: 'Observers have commented adversely on the taste of synthetic margarine but all have had to agree that it could be eaten quite well. It is claimed that these margarines have very good keeping qualities.'

The manufacture of edible fat from petrol or from coal has a romantic attractiveness. Dr. Johnson attributed the interest inherent in a woman making a public speech, as of a dog walking on its hind legs, to one's surprise at the feat being possible at all. Margarine from petrol may likewise fall into this category. During World War II, the availability of coal in Germany was greater than that of butter. The German scientists themselves have admitted that the economic justification of trying to manufacture butter from coal does not exist under normal circumstances. Furthermore, on general grounds it can be reasoned that it is better to eat fat from annually renewed vegetable foods or from the foods which can be produced by processing feed through animals rather than consume fat manufactured from even a small fraction of the wasting asset of mineral wealth.

One method of creating fat which is free from this criticism of economic illogic has been brought almost to a practical basis. It is the cultivation of special strains of yeasts and moulds which contain substantial amounts of fat. Essentially, this cultivation involves the conversion of cheap sugar and inorganic nitrogen into fat. The process which has probably most nearly approached success is a German one, in which the micro-organism, *Oidium lactis*, is grown on the waste lactose remaining in whey after the manufacture of cheese. The organism proliferates best in the presence of air, and is consequently grown on canvas sheets the backs of which are sprayed with the whey medium. In a different variation of the process, straw treated with sulphuric acid is used as a medium. It has been calculated that five tons of fat can be made through the intermediacy of this organism from one hundred tons of straw.

Oidium lactis is a mould. Two types of yeast, *Torulopsis lipofera* and *Rhodotorula gracilis*, have also been used as fat producers. These organisms are capable of producing about 10 to 15 tons of fat from each 100 tons of the sugar on which they are grown. The fat from *Torulopsis lipofera* has been examined and found to resemble a typical animal fat. Up till the present, fat has only been produced by these organisms as a scientific *tour de force* and consequently at an uneconomic cost. Nevertheless, the fact that it can be done raises the possibility that these yeasts and moulds, which reproduce themselves in hours, may be the food crops of the future.

We have discussed in general terms the technical problem of converting mineral oil into edible fat. In brief, the chemist has to attach a reactive terminal group containing oxygen on to the end of the purely hydrocarbon chain which is the chemical unit of mineral oil. Without this reactive 'tag', the mineral oil cannot be utilised by the body. Almost all of a teaspoonful of liquid paraffin swallowed can, if need be, be recovered intact in the excreta.

From time to time, ingenious people—either unscrupulous or ignorant of biochemistry—have attempted to take advantage of this very inertness of mineral oil by proposing that it be used as an ingredient in 'slimming' diets. Although its cause is not fully understood, obesity can be checked, if not cured, by a stringent restriction in calories. Since fats are of all foods the most concentrated source of calories, unfortunate people trying to get thin can never eat fried dishes with a clear conscience. It seemed, therefore, a simple act of kindness to sell them (at a high price) liquid paraffin as a 'reducing' cooking oil.

Unfortunately, mineral oil has two harmful effects. In the first place, vitamin A is very soluble in it. Thus, as it passes through the alimentary tract it soaks up vitamin A from the articles of diet which contain it and eventually, when it leaves the body, it carries the vitamin A with it. Its second harmful effect is probably more dangerous. Although mineral oil is chemically inert, when it becomes broken down into very small globules, some of it seeps into the blood stream and eventually ends up in the liver. Here it exerts a chronic clogging effect. These are the reasons why mineral oil is now forbidden in Great Britain as a food ingredient.

Enough has been said about the chemistry of the true edible fats and oils to show that the fat technologist has a complex task to perform. This task is a real contribution to a modern community. A vegetable oil, such as soya-bean oil or ground-nut oil, is commonly obtained by crushing the beans or nuts. The crude oil obtained by this process is contaminated with water, resins, gums and various decomposition products and not all of the fatty acids in it are combined with glycerine, as they must be if a good quality 'neutral' oil is required. Some are in the form of 'free' fatty acids. A crude oil contaminated in this way is cloudy and sour, and rapidly deteriorates and becomes rancid. The first stage of the process of oil refining is, therefore, the treatment of the crude oil with caustic soda or soda ash. The mixture is heated by steam coils, the 'free' fatty acids become converted into soap and the oil can be separated from them in machines similar to cream separators. Most of the resins and other contaminents are removed, mixed with the soaps. The oil is washed with hot water to remove the last trace of soap and is then heated to remove any residual moisture. Next, the hot oil is mixed with bleaching clay, the fullers earth mentioned in the Bible, which absorbs the colouring matter from it. The clay after it has done its work is removed by filtering.

A natural oil, even when it has been refined, has a characteristic smell and taste. If the oil is to be hydrogenated and turned into 'cooking fat', or if it is to be used as an ingredient of margarine (and nowadays all edible oils with few exceptions are used for these two purposes), its native taste and smell must be removed. This is done by heating it to a high temperature in a vacuum and passing steam through it. The 0·2 per cent. of ingredients which give the oil its flavour and aroma are carried away in the steam.

Arachis hypogaea is the single largest oilseed crop in world production. This is the ground-nut, peanut, earth-nut, monkey-nut or goober of everyday speech. It is an annual crop, botanically related to peas and beans. In 1946, 1,650,000 tons of ground-nut oil came on to the market, compared with 1,500,000 tons of soya-bean oil, 1,200,000 tons of cottonseed oil, 900,000 tons of olive oil, 700,000 tons of coconut oil and 600,000 tons of sunflower-seed oil. Ground-nuts are a versatile crop and their culture improves the fertility of the soil. They form, therefore, an obvious first choice in any plan to increase the world supply of vegetable oil. Furthermore, when the oil is extracted from them, a useful protein food for cattle remains.

The extraction of oil from ground-nuts, although simple in principle, is a laborious technical process. After they are harvested, the nuts are passed through machines which split the shell open between revolving knife edges or corrugated rollers, and then through beaters which shake the kernel out of each nut. The kernels are separated from the broken shells and adhering soil by varying methods ranging from the wind winnowing of native growers to complicated systems of vibrating screens combined with air separators. Next, the cleaned nuts are flattened into flakes by being passed through heavy, steel rollers.

The commonest method of extracting the oil is to cook the flaked nuts in 'live' steam at a temperature of about 260° F. for fifteen or twenty minutes. This cooking breaks up the structure of the cells of the nut tissue and thus permits the oil to escape. The cooked flakes are, therefore, put into flat wooden moulds about two inches deep and wrapped in woollen cloths. In the latest types of presses, finely perforated metal plates obviate the necessity to use cloth. When moulds are used, fifteen or sixteen are put into the press together, and pressed by hydraulic power for about three-quarters of an hour with a force of 1½ tons to the square inch. When the pressing is complete, the cake is taken out of the press by hand and the edges that have extruded pared off for re-pressing. The whole business in its present form requires a good deal of labour and the work of handling the hot and oily cakes is heavy and unpleasant. The cost of labour steadily rises as people doing manual work gradually come to realise that by taking appropriate political action they can enjoy an increasing share of the benefits which the modern technologists have to offer.

As soon as the price of getting people to lift heavy, greasy oil cakes rises very much above its 1950 level, continuous screw or expeller machines, as yet uneconomic in most places, will come into use. The principle of the use of these machines is to pass the uncooked nuts in a series of buckets on an endless chain through a stream of petrol or some other suitable solvent. Alternatively, they may be pushed through the solvent by means of a perforated screw. The whole business takes place in an enclosed container to prevent the petrol evaporating or catching fire. The oil is recovered at the end of the process by distilling off the solvent. Thus it can be seen that the production of oil, be it from ground-nuts, sunflowers or soya beans, in the enormous quantities needed to provide the customary amounts of margarine and cooking fat which the urban communities of the West have come to believe essential, is a complex, expensive highly technical procedure.

Fats and oils, when they are freed from moisture, will keep for a substantial length of time. When they deteriorate, two chemical forms of rancidity occur. The first arises from the presence of free fatty acids. These can be removed by the processes of refining, and their formation can be prevented by ensuring the absence of moisture. The second is oxidative rancidity, which is caused by the interaction of the fat with oxygen from the atmosphere. If fat can be stored at a sufficiently low temperature, say, 15 to 25° below freezing point, it can be kept without damage to colour or flavour for between one and two years, even if it is in the form of margarine which contains a proportion of moisture.

It is a curious paradox, however, that many crude fats and oils contain natural substances, technically known as 'anti-oxidants', which protect them to some degree against the development of rancidity. These substances are removed during the course of refining. It is a short step, therefore, for the food technologist to set to work to find chemicals which can again be mixed with refined fats and which will act as preservative 'anti-oxidants'. Many of the most efficient of these, for example, *hydroquinone*, have toxic effects and cannot legitimately be used; but harmless substances, such as lactic acid, tartaric acid or citric acid have been quite widely employed as 'anti-oxidants' in amounts of 1 part to each 15,000 parts of fat. Phosphoric acid is also used. Unfortunately, there is some disagreement as to the real effectiveness of these materials, and the hunt has been extended to more esoteric compounds. So now appears *butyl-hydroxy-anisole* and many more; and we are back again, with oils and fats, as we were with flour, in the realm of 'improvers'.

One of the most popular of the new 'anti-oxidants' which has already come into wide use in the United States is NDGA, or *nor-dihydro-guaiaretic acid* to give it its full name. Nothing is known against this substance, but one would not, in the ordinary course of events, go out of one's way to eat it. An even newer substance, thought to be of equivalent activity is *nor-conidendrin* which, somewhat curiously, has been prepared from waste liquor arising from the manufacture of paper from Western hemlock. The hemlock in this instance is a tree, and not the plant from which the poison administered to Socrates was extracted.

We have likened 'anti-oxidants' in fat to 'improvers' in flour. During the course of the investigation of 'improvers', it was discovered that *ascorbic acid*, which is the vitamin C of oranges and lemons in pure form, possessed a powerful 'improving' effect. This was hailed as an important discovery because there could be no possibility of small amounts of this vitamin having any harmful effect, and the only reason why *ascorbic acid* is not used more widely is because it is more expensive and more difficult to make than chlorine dioxide.

A similar although less well authenticated observation has been made in the field of 'anti-oxidants'. Workers at the National Chemical Laboratory of India in Poona have claimed that many of the condiments and spices traditionally added to fats and oils in the East possess pronounced 'anti-oxidant' effects. Among those with the highest potency are red chillies, cinnamon leaves, turmeric, dry ginger, black pepper, nutmeg, cloves, cinnamon bark, green chillies, green ginger and, finally, onion. This has little present application to the modern oils and fats industry of the West, but it is, at least, an interesting side-light on a technical problem.

The very big industrial unit is the rule in the oils and fats industry; but, whatever opinion one may hold of the financial and administrative organisation of the industry, there is no doubt that, without the work of the technologist, the supply of the fats customary to a civilised diet would be impossible. It is the technologist who takes out the dirt, the taste and the smell from whale oil, coconut oil, seseme or ground-nut oil and converts them all into margarine or cooking fat which, if not exciting, is at least uniform and unobjectionable. Surely to such a one we cannot grudge a few adventures with 'anti-oxidants'. And, when they come, we may even welcome his synthetic fat made from coal and his fermentation fat derived from yeast.

There are many new tasks for the fat technologists. Between 1934 and 1938 the annual export of oils and fats from Manchuria was 516,000 tons; in 1947, none was exported. Indonesia used to export 530,000 tons and in 1947 exported 97,000 tons. Similar changes are occurring in the trade of China, India, Malaya, Argentina and other sometime big producers. Thus future shortages of traditional supplies may confront the technologist with new problems.

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Sugar and Sweeteners

In the modern civilised industrial world, the topics about which there is controversy and upon which public attention becomes fixed seem to be chosen almost at random. For instance, in such a matter of principle as the denial of justice, extensive public mischief may exist and yet no general excitement be felt, whereas some small incident, perhaps relating to a particular individual or locality, may arouse a storm of protest. This fitfulness in the public's reactions is strikingly illustrated by its attitude to refined flour, on the one hand, and refined sugar, on the other. As we have seen, in the brown bread controversy, one of the chief arguments put forward by the protagonists of brown bread has been based on the fact that each 1,000 calories of carbohydrate requires the presence of between 0·2 and 0·5 milligrams of vitamin B_1 or it will be harmful to health and will, in the last extremity, give rise to beri-beri. The amount of white, refined flour that provides 1,000 calories provides only 0.24 milligrams of vitamin B_1, and bread made from it will provide less. For this reason, say the supporters of brown bread, white bread is bad and ought to be suppressed. Now, 1,000 calories' worth of white, refined sugar contains no vitamin B_1 at all. Yet, through the inexplicable vagaries of public attention, no objection has been raised to it on the grounds of vitamin deficiency and no proposals for enforcing the consumption exclusively of brown sugar, or white sugar enriched with vitamins, have been mooted.

It must not be assumed that the nutritionists have failed to criticise sugar as an element in diet. On the contrary. But they have been sufficiently broadminded to accept the prevailing demand for sweetness, and have been prepared to tolerate a certain consumption of sugar. Even a nutritional expert, it may be, has a fondness for sugar in his tea. But, while the nutritionist's grudging acceptance of sugar is explicable on several grounds, the absence of serious technical proposals to improve sugar's nutritional value is surprising.

The attitude of the nutritional scientist towards sugar is well epitomised in a statement of the experts of the Ministry of Health in London which was made in 1947 at a meeting of a learned society at which the post-war food needs of the United Kingdom were discussed. The statement was as follows:

> Excessive consumption of sugar is not looked on with favour because it displaces more nutritious foods from the diet, tends to pervert taste and blunt the appetite of children, and seems to play a part in causing dental caries. Nevertheless, well-balanced diets can be achieved containing fair amounts of sugar, as long as the flour is of high extraction. Moreover, sugar is a good and easily assimilated source of carbohydrate. Weighing up the advantages and disadvantages, we concluded that a consumption level between the pre-war one and that of 1946, which was insufficient for domestic purposes, would meet the tastes of the majority, with a minimum of dissent from nutritional experts.

Sugar cane is a member of the grass family, which also includes wheat, oats, maize and other cereals. Sugar cane, however, towers above them all, sometimes attaining a height of twenty feet. For the extraction of the sugar, the cane is crushed in a series of heavy, steel rollers. The first set of three rollers squeezes out most of the sugar-containing juice. Water is then added to the crushed stalks; and when they are passed through a second and often a third set of rollers, additional sugar is squeezed out with the water. The sugar-cane juice may be treated in a number of ways. It is most commonly purified by the addition of sufficient lime to neutralise its natural acidity and make it very faintly alkaline. It is then heated to boiling point and allowed to stand, when albumin and other proteinaceous substances and most of the suspended impurities settle out. This treatment with lime is called the 'defecation' process. The treatment with lime cream can also be combined with a simultaneous treatment with sulphur-dioxide gas. This causes other impurities, including pectin and gum, to settle out as well.

After the sugar has been extracted from the cane and the juice purified by one means or another, the bulk of the water must next be evaporated off. About 70 per cent. by weight of the liquor is evaporated in an elaborate plant called a 'multiple-effect evaporator'. The syrup so formed is boiled up again in a vacuum pan until crystals of sugar begin to form. This mixture of syrup and sugar crystals is called *massecuite.* The sugar is removed in a centrifugal machine which works on the same principle as those often used domestically for drying clothes after they have been washed in a washing machine. The liquid remaining, after removal of this crop of sugar, is boiled again and a second crop of sugar obtained. It is then boiled finally for the third time to obtain the last available sugar. The final, thick, black, residual treacle is called *molasses.* Even though as much sugar as possible is got into crystalline form, the molasses contains in it about 50 per cent. Molasses, usually partly purified, appears in the domestic diet as 'black treacle'.

Sugar, after it has been recovered, must be refined. Otherwise, quite apart from any objection to its dark colour, the sweet taste, for which quality it is primarily consumed, will not be obtained without the persistent flavour of molasses. White sugar-loaves were manufactured from sugar cane many centuries before the present refining process was invented, the early system being probably derived from the Arabs. The boiled syrup was allowed to crystallise in conical moulds. A dunce's cap of crystals formed inside the mould, and the mother-liquor drained away through a hole at the pointed end. A mixture of clay and water was then poured in and allowed to percolate slowly through the sugar. By this means the dark coloured molasses was absorbed and washed away. This operation, termed 'claying', was repeated until the crystalline mass became sufficiently white. A very similar method is still used in India, a certain type of leaves being substituted for the clay. Such sugar-loaves were first imported into England in 1319, and appeared at the coronation banquet of Henry V in 1413.

In modern refining processes, the sugar crystals are first washed with a small amount of water to remove adhering molasses and some impurities. Next, the sugar is dissolved in sufficient water to form a syrup and is filtered through a cloth. The syrup is then passed through a filter made of 'bone char'. This material is charcoal made from bones. The use of this material is of some antiquity and dates back to 1830, when the process was patented. The bone char absorbs the colouring matter from the syrup. An important advantage is that, after it has been used, the bone char can be roasted and is then ready for the treatment of another batch of syrup. After bone-char 'bleaching', the syrup is boiled and the sugar allowed to crystallise. It is then again recovered on a centrifugal machine. Part of the syrup can, of course, be sold as such to people who want to buy 'golden syrup'. For this purpose, the sucrose is first partially broken down into its components, glucose and fructose, which are more soluble and hence less likely to crystallise out of the syrup.

As an alternative to the refining process with bone char, a white sugar can be produced by careful washing and steaming of the crystals recovered at the original centrifugation. Such sugar, although 99·8 per cent. pure, is often 'blued' with ultramarine blue to make it appear whiter. Yellow crystals or 'Demerara sugar' are recovered without washing. The agreeable colour and flavour is due to the adhering film of molasses. It is, however, not infrequently imitated by dying white sugar, made from cane or beet, with aniline dyes. In some processes the sugar is bleached with chemical agents such as hydrosulphite or sulphurous acid.

The manufacture of sugar from beet was first attempted in 1796, although the presence of sugar in beet and other root crops was discovered by a Berlin chemist, Marggraf, in 1747. The effective stimulus to the production of beet sugar was, however, administered by Napoleon in 1806; and, before long, beet containing high concentrations of sugar had been produced and workable methods for extracting the sugar from it evolved. The present process is to cut up the roots into thin slices and soak them with heated water in a series of vessels called 'diffusers'. The diffusion juice is purified by treatment with lime and by carbonation, and thereafter concentrated and handled in a similar way to cane juice. Sugar obtained from beet is, of course, identical in chemical composition with sugar from cane.

The process of sugar manufacture is, unfortunately, well suited to the destruction of the original vitamins present. For example, of the vitamin B_1 in the sliced beet tissue, 25 per cent. is left unextracted in the beet pulp. Of the quantity remaining, 90 per cent. is destroyed during the concentration and clarification of the diffusion juice, and only 5 to 6 per cent. remains in the molasses. A second vitamin, *riboflavin* (vitamin B_2) is largely adsorbed on the lime cake used in clarification. About 2 per cent. is found in molasses. A third vitamin, however, *nicotinic acid* is almost entirely accounted for in the molasses.

In the milling of flour, part of the original amount of vitamins in the grain goes into the milling offals removed in the process but some remain. In the manufacture of sugar, much of the vitamin content is destroyed by the heat, the alkalinity of the lime or the bleaching action of sulphurous acid. Part is found in the molasses and a very little, therefore, is to be expected in genuinely 'impure' products such as Demerara sugar. None remains in the purified white sugar of common use.

Sugar, in fact, owes its place in the modern diet almost entirely to two properties—its taste and its preservative power. Of these, the first is by far the most important. The fact that sugar is a concentrated source of dietary energy is incidental. If it had not been sweet, no one would have troubled to develop its production.

The desire for sweetness is a remarkable phenomenon. Between the middle of the nineteenth century and the middle of the twentieth, the consumption of sugar in England increased five-fold. This was, no doubt, partly due to a fall in price by approximately half, but it seems also attributable to an increased urge for sweetness. If the industrial progress for which Great Britain is striving ever leads to material wealth comparable with that of the United States, the consumption of sugar can be expected to rise still higher to enable men and women as well as children to consume the large amounts of 'candy', syrup, sweetened ice cream, carbonated beverages and confectionery inherent in the American way of life. In 1938, the consumption of sugar in Great Britain amounted to 110 lb. for each person; in 1948, the figure was 91 lb.

With the exception of sugar and perhaps manufactured cooking fat, all foods are composed of mixtures of several of the many diverse nutrients which are required to make up a 'balanced diet'. Sometimes, as we have seen, foods also contain chemical substances added for technical purposes as 'improvers', 'stabilisers' or just 'food additives'. Bacteria also in spite of the barriers and discouragement opposing them, may sometimes gain entrance. Sugar is in a different category. The efficiency of refinement is such that the article marketed by the grocer is not only *not* a mixture of different nutrients, it is a single chemical entity, *sucrose*, more than 99 per cent. pure, free from added substances (except occasionally a trace of 'blue') and free from bacteria.

Although sugar is not primarily eaten for its nutritional value, it plays a significant part in the diet. Sugar is very readily available as fuel to the body. The danger of its deficiency in vitamin B_1 to implement its physiological 'combustion' has already been mentioned. Apart from this, the calorie value it supplies is valuable to an individual needing supplementary energy. Because the liquid used to make a cake or, for that matter, to make a cup of tea, takes up little more space whether it has, say, an ounce of sugar dissolved in it or not, sugar is very well adapted to raising the energy value of food without increasing its bulk. The ounce of sugar so painlessly, even pleasantly consumed adds 108 calories. To get so much from, let us say, potato, would require the ingestion of more than a quarter of a pound. Hence, for heavy workers, or for children who expend a great deal of energy in physical activity, sugar is an agreeable and compact fuel. To the same degree, of course, sugar is fattening to those who consume it without physiological need.

A further point of some interest relating to the influence of sugar on health, is its effect on teeth. It is popularly believed that sugar is bad for the teeth. This is broadly true, but the harm it does is a secondary and not a primary effect. Dental caries, what the ordinary person calls 'decayed' teeth, arises from the destruction of the enamel by acid. There is in one's mouth ordinarily a strain of bacteria, called *Bacillus acidophilus*, which is capable of converting sugar into acid. At this point, however, what appears to be a simple instance of cause and effect begins to become more complicated as we discover more about it. For example, there is no direct relationship between the number of these acid-forming bacteria in the mouth and the development of caries. Nevertheless, in a trial carried out by the Dental School of University College, Dundee, it was found that fifty experimental children developed more bad teeth when they were given an additional 'fudge tablet' or 'macaroon bar' each day than they did when they were not. The danger of such sweets seemed to depend upon their tendency to lodge in the teeth and form a 'plaque' which would hold the sugar, and upon which the bacteria could base themselves. Sugar in solution cannot lodge in the teeth.

But even the theory that the lodging of starch and mucin as a 'plaque' in the teeth accumulates bacteria, which ferment sugar into caries-causing acid does not meet all the facts. South African Bantus, living under their native conditions, chew a great deal of crude sugar cane but have excellent teeth. It has since been found in laboratory experiments on teeth in test tubes that calcium and phosphorus present in the raw cane exert a protective influence, and that when these substances are added to refined sugar the same protective effect ensues.

It seems clear that even though the acid which destroys the dental enamel is formed by the bacteria, even though starch and other food components form the 'plaques' which enable the bacteria to gain a lodgement, and even though protective substances may be present in certain foods, nevertheless, it is sugar which provides the medium which *may* be turned against the integrity of the teeth. To that extent, its increasing consumption raises an element of danger to health. But many things in the regimen of modern civilised man are dangerous. Tobacco and alcohol have their own hazards, while the mortality from the use of motor cars is even greater than that attributable to these other indulgences. In return for the possible dangers arising from the use of sugar, we enjoy its two desirable attributes—its sweetness and its technical qualities.

The exact physiological nature of sweetness is not properly understood. All that can be said is that we like sweetness and that it is sweetness we like. It is reported that the American chemist, Fahlbert, sat down to supper one evening in 1879 and noticed that his bread tasted sweet. He traced this sweetness to his hands, which we must presume he had not washed, and thence to a substance, *ortho-sulpho-benzimide*, with which he and his colleague Remsen had been working in the laboratory. This material is now well known under the name of saccharine.

Saccharine is between five hundred and six hundred times as sweet as sugar, weight for weight; and, when used under properly controlled conditions, its taste is barely distinguishable from that of sugar. For example, orange squash, lemon squash and suchlike drinks are commonly manufactured with sugar. When in Britain during World War II, the official sugar allocation for this type of manufacture was restricted, the sweetness was maintained by the appropriate addition of saccharine. It would be a bold man who could promise unfailingly to distinguish the substitution. Many other food products contain undetected saccharine as a sweetening agent when sugar is unavailable. Only when saccharine is used under inappropriate conditions, for example, if it is boiled in tea, does a 'metallic' flavour appear mingled with the sweetness.

The powerfulness of the flavour of saccharine makes it necessary to use only very small amounts. It can, therefore, be classified as a mere 'food additive', and is in sharp contrast to sugar, which forms a material proportion of those foodstuffs with which it is incorporated. It appears that the small amounts of saccharine consumed are absorbed and pass into the blood stream, but are thence excreted quantitatively by the kidneys and can be recovered intact in the urine. No harm has ever been proved to have arisen from the process. Since the discovery of saccharine, a number of other chemical substances have been isolated possessing sweetness greater than that of sugar. One of these, *normal-propoxy-2-amino-4-nitrobenzene*, is claimed to be four thousand times as sweet. Of more practical significance than this is a substance, *para-phenetyl-urea*, discovered by Berlinerblau in 1883, and now called 'dulcin'. Although dulcin possesses slightly less than half the sweetening power of saccharin, its taste is 'softer' and it does not exhibit that bitterness which is one of saccharine's disadvantages. The principal technical disadvantage of dulcin itself, however, is that it is very difficult to dissolve it in water. Much work has been done to discover whether dulcin is toxic. The first experiments failed to show that, in the amounts likely to be used in practice, it caused any harm to laboratory animals, but more recent investigations suggest that it *may* cause injury to rats if they consume it for two years on end.

Purely on the basis of sweetening power, dulcin is slightly cheaper than sugar but approximately twice as expensive as saccharine. It has been used successfully by manufacturers of soft drinks, usually in combination with saccharine. It is perhaps a sign of the technological age in which we live to find the Fruit and Vegetable Preservation Research Station at Campden in Gloucestershire, a research unit receiving Government support, recommending the use of dulcin for sweetening canned beans in tomato sauce. It has also been added to canned fruit, pickles, sauces and chutneys. Remarkable as are the sweetening properties of dulcin, even its most enthusiastic protagonists recommend its use as a supplement to sugar rather than as a complete substitute.

Apart from ingenious compounds such as saccharine and dulcin, the chemical nature of which is entirely different from that of sugar, there are other members of the sugar family which can provide sweetness to the diet. If the sweetening power of sugar be given the arbitary value of 100, *fructose*, which is a major constituent of honey, possesses a sweetening power of 170 and glucose has a value of, say, 75. Starch from different sources can be broken down by means of acid or by a biological process; corn starch, for example, can be converted into corn syrup which may possess a sweetening efficiency about half that of sugar.

The technical property of sugar which, together with its sweetness, makes it so valuable to the food manufacturer and the housewife alike, is its ready solubility in water. Because more and more sugar can be dissolved in water until the solution becomes syrup, sugar imparts an agreeable 'body' to those mixtures in which it is incorporated. Thus, even though a 'soft' drink containing saccharine or dulcin or both may be as sweet as one containing sugar, it will be 'thinner' and more watery in consistency. Similarly, made-up custard powders and manufactured cake and Christmas pudding, although prepared according to carefully thought-out formulae, will be less satisfactory when they are made with a chemical sweetening agent than when they are made with sugar. This arises from the fact that the subjective impression made by a food on the person eating it is a mixture of taste, smell, the feeling of texture and, as we have already discussed, sight as well. The chemical sweetening agent only contributes to the sense of taste.

The high solubility of sugar in water which gives 'body' as well as taste to food and drink provides a further technical advantage. Just as fresh-water fish are not equipped by nature to live in the sea, where the concentration of salts is too high for them, so are many bacteria incapable of living in concentrated solutions of sugar. Hence, fruit which is boiled in sugar solution can be preserved as jam; the high concentration of sugar prevents the growth of the micro-organisms which would otherwise cause spoilage and decay.

When sugar was first brought to Europe, it was an expensive luxury. Today it is a cheap necessity. When there is a shortage, the modern citizen feels that he is suffering hardship and sets out to discover alternative sources to the cane and the beet. Recently, for example, the Indian Institute of Sugar Technology at Kaupur has suggested a method for manufacturing sugar from the juices of the date, brab, coconut and sago palms. The technical difficulty of utilising the sugar present in these palm juices is that they ferment very quickly. The ingenious proposal has been made that sulphanilamide, the basic member of the 'sulpha' drugs of which M and B 693 is the best known, should be added to prevent fermentation during the time the juice is being collected.

This is a beautiful example of the application of modern technology to food. Up till now, the juice of these palm trees has been allowed to drip out of the flowering shoots of the tree into a pot. Without the benefit of sulphanilamide, the juice in the pot easily ferments and turns into toddy. When it is collected for its sugar, the juice is boiled until it is syrupy and then poured into pots to set. The solidified sugar is called 'jaggery' and is either eaten at home or sold to the sugar refineries. The use of an antiseptic agent, if it ever becomes general, will enable the juice to be collected in bulk and processed centrally in an up-to-date industrial unit. And thus we shall see once again the extinction of one more cottage industry.

Although a shortage of sugar represents a hardship to modern industrial man, the sugar industry lives traditionally in chronic fear of 'over-production'. For this reason considerable thought has been given to uses for sugar other than as food. Whereas coal and oil—the normal sources of industrial power—are wasting assets, which may one day reach exhaustion, sugar, which is a compound of carbon equivalent to coal and oil as a source of power and of chemical intermediaries alike, is perennially renewed and owes its existence to the energy of the sun and the carbon dioxide of the atmosphere. Furthermore, agricultural progress has been such that methods of cultivation are now available by which it is possible to produce 50 tons of sugar cane per acre, the equivalent of about 4½ tons of sugar.

The price of raw sugar of about 98 per cent. purity in 1949 was £28 a ton f.o.b. This was still several times the cost of coal so that its direct use as fuel was not to be considered. Sugar, however, can readily be converted into a number of useful chemicals, and it can be transformed into many of these without the necessity of purification. Molasses, for example, containing 50 per cent. of sugar, can be fermented to produce industrial alcohol which is valuable in itself as a fuel and which successfully competes in price with synthetic alcohol. The alcohol, however, is probably most important as a starting material for the synthesis of butadiene from which synthetic rubber is made. Other products derived from alcohol are acetic acid, ethylene, ethylene glycol, ethylene oxide and ethyl chloride all of which are of industrial importance.

The sugar in molasses is fermented into alcohol by yeast. Dr. Weizmann, President of Israel, was in his earlier years noted as a chemist. His most outstanding achievement in this field was the discovery that a certain mould could ferment sugar, with the resulting production of acetone and butanol. This acetone-butanol fermentation is now carried out on a large industrial scale. Butanol is used for many purposes, the most important of which is probably the solution of cellulose nitrate lacquers. Acetone is even more versatile. It has recently been converted into a substance called *pinacol* from which synthetic rubber can be produced. *Pinacol* is also used to manufacture neohaxane, while acetone itself is the basis of the production of *isopentane*. Both these substances are valuable as ingredients of aviation fuel.

Yet another fermentation product of sugar is citric acid. Formerly, citric acid was used in medicines and soft drinks but more recently it has been found useful in the manufacture of plastics and for conversion into synthetic resins. These substances, like yeast (which we discussed in an earlier chapter), are derived from sugar by processes of biological fermentation. But as a chemical raw material, sugar offers even more diverse possibilities to the scientific technologist, who only awaits some relaxation of the national preoccupation with sugar as a food to show what really 'useful' substances he could produce from it. For instance, sugar can be converted by *allylation* into *allyl sucrose* which give wood a hard and glossy surface when painted on it. *Sucrose octa-acetate* can be used as the unbreakable layer of the non-splintering glass used for motor-car wind-shields. Curiously enough, although sugar itself owes its place in the world to its sweetness, its derivative *sucrose octa-acetate* is extremely bitter and can be used as a medical stomachic or as the bitters in gin and bitters. Alternatively, this bitterness can be employed as a 'denaturant' to render industrial alcohol undrinkable.

As can be appreciated, the attractiveness of sugar in war-time is as a source of industrial alcohol for fuel and more recently, as a basis for synthetic rubber. Recently, advances have been achieved in the economy of conversion into *sucrose octa-nitrate*, which may be used for blasting operations. A further chemical process has been evolved by which sugar is split up into two substances, *mannitol* and *sorbitol*. Both these are useful in the modern industrial world, the first as a basis for a safe detonator to set off rifle bullets and the second as a basis for the synthesis of vitamin C.

As a food, sugar is a curiosity by being an almost pure single substance in contrast to most other foodstuffs, which are mixtures. Of itself, sugar is a wholesome substance, possessing a conspicuously great energy value. It is, indeed, its high energy value combined with its chemical purity that comprise its danger to health, in that it does *not* contain that admixture of 'trace substances' making up the 'vitamin B-complex' which are needed for its physiological utilisation in the human body.

If sugar were merely a pure food of high energy value, it would not interest many people as an article of diet. Had it had no further dietary properties, it might before now have been used almost exclusively for industrial purposes, some of which we have just summarised. Sugar, however, is sweet and it is for its sweetness, combined with its ready solubility, that it is prized, even though the scientist may consider the desire for sweetness a frivolous one. We can only record that people like sweet things and find the combination of properties possessed by sugar the best way to obtain the sweetening they want. If the economic climate allows people to buy the increasing quantities of sugar they desire, then, since the human capacity for calories is limited and since, in consequence, the consumption of more sugar inevitably leads to the consumption of less of other foods, almost all of which are better 'balanced' than sugar, we can almost certainly prophesy that the sugar of the future will be 'reinforced' with vitamins and perhaps with protein as well.

10

Vegetables

It is a commonplace of social small-talk to say: 'Vegetables never taste so good as when they come out of your own garden.' It is profitless to examine the absolute truth or otherwise of this statement. Enjoyment is a subjective thing and 'a dinner of herbs where love is' is notoriously more satisfactory than 'a stalled ox and hatred therewith'. Nevertheless, it is interesting to review what is known of the chemical composition which gives vegetables, on the one hand, the qualities we recognise in them as pleasing articles of diet and, on the other hand, their particular nutritional significance. We can then see to what extent the handling they receive during their transport and marketing affects their quality, and hence whether the sentimental nostalgia for home-grown produce is, indeed, founded on fact.

The greengrocer handles five different categories of vegetables. That is to say, 'greens', such as cabbage, cauliflower, Brussels sprouts, spinach, turnip tops, lettuce and watercress represent a separate group, which is quite different from either dried peas and beans, or turnips and swedes. Then we have two further groups—potatoes, which deserve to stand alone, and carrots, which also merit separate consideration. In those countries where they are available, sweet potatoes can be classified with the carrot group.

People eat vegetables, as they eat other foods, because they like them or because they are accustomed to them, or sometimes because they are hungry. So far as the scientist can interpret the consumption of vegetables in nutritional terms, it can be said that the vegetable groups of (*a*) 'greens', and (*b*) turnips are remarkably ineffective for the relief of hunger, that is, they do not provide calories. The property which makes them useful in the diet—a property which they share also with potatoes—is that they contain vitamin C.

This substance, the chemical name for which is *ascorbic acid*, is an essential for life and health. The point of practical interest, which has caused intense controversy in scientific circles, is—how much vitamin C is necessary? Acute deficiency of vitamin C causes the disease, scurvy, which gave rise to a devastating mortality among seamen on long voyages in the seventeenth and eighteenth centuries. But not even the British Ministry of Food, which spent large sums of money on advertising the 'health-giving' values of fresh vegetables during World War II, would now pretend that anyone in Great Britain was at all likely to have developed scurvy, however great economies had been practised at the green-grocer's shop. No one contracts scurvy if he or she is receiving 10 milligrammes, or so, of vitamin C a day. This amount is provided by about one mouthful of boiled Brussel sprouts, or an ounce of properly boiled cabbage, a helping of potatoes, half an ounce of orange or two blackcurrants. Indeed, ever since the introduction of potatoes into the civilised world, the disease, scurvy, has dwindled in importance to a mere medical rarity.

The preoccupation of the public-health doctor and the nutritionist with popularising vegetables with the general public, with the dissemination of concentrated orange juice, rose-hip syrup and blackcurrent *puree* among children, and with the issue of vitamin-enriched lemonade powders in the 'K-rations' of U.S. troops is based on more subtle fears. When people eat a diet deficient in vitamin C, before scurvy appears, a softening, reddening and bleeding of the gums occurs. Now, among the poorer classes of the community, diseased and bleeding gums are by no means uncommon. These symptoms are usually due to infection arising from the use of dirty cups and utensils, but it is, of course, *possible* that they may be due to vitamin C deficiency. Similarly, true vitamin C deficiency may cause a certain affection of the skin. This condition may also arise from a number of other causes, one of which is suspected to be an unduly infrequent use of soap.

In spite of the doubts which arise whether any recognisable, even if minor, symptom of ill-health is really due to a partial deficiency of vitamin C. the fact that it *may be* has led those responsible for the health of Western communities to cast about for some indication, other than the appearance of clinically recognisable scurvy, to show that that well-being is suffering through lack of dietary vitamin C. The sign they chose was the following. If a normal individual who has been eating, say, 30 milligrams of vitamin C a day in his food is given a dose of about 600 milligrams of pure vitamin, his body will soak up the surplus. If on the following day he is given another 600 milligrams, he may soak that up too, and he may be able to do this again on the third day. Eventually, however, his capacity to absorb surplus vitamin C will be reached, and any subsequent excessive dose will be excreted in his urine. He is then said to be 'saturated'.

The less vitamin C an individual normally eats in his diet, the longer it will take to saturate him. Conversely, of course, the more he eats, the sooner he will be saturated. Indeed, if a man customarily consumes somewhere about 75 milligrams of vitamin C a day, his tissues will be in a constant state of saturation and he will excrete into his urine the first 600 milligram dose he is given. And because a 'saturated' individual cannot possibly be suffering from even minor symptoms of vitamin C deficiency, still less from scurvy, it came to be assumed, particularly in the United States, that, in order to be as well as it was possible to be, a person *needed* to be saturated. However, the British failed to show any evidence whatever of scurvy, or its premonitory symptoms, although during the years of World War II they were eating less than 30 milligrams of vitamin C a day. Partly for this reason it gradually became accepted, even by those nutritionists who took their public responsibilities most seriously, that saturation was not necessary for health.

All this leads us to the premise that, although in the handling of vegetables it is desirable to lose as little of their vitamin content as possible, it is going beyond the scientific facts to believe that vegetables from which the vitamin C has been lost are entirely valueless. A far more important practical consideration is the fact that those vegetables from which the vitamin C has been lost are those which are wilted and damaged, or otherwise of poor quality. In fact, it might almost be suggested that an analysis of vitamin C-content might usefully be carried out at the market, not as a public-health precaution to prevent disease, but rather as a measure of freshness and quality to ensure that an article of good colour and flavour should reach the consumer.

We have said so far that, in the limited view of the nutritional expert, (*a*) 'greens' and (*b*) turnips are eaten for their vitamin C content. In saying this, we have purposely postponed any extended reference to potatoes, which deserve a discussion to themselves. If we still stick for a moment to the purely scientific outlook, it can further be stated that both 'greens' and carrots make a useful contribution to the vitamin A-content of the diet.

Vitamin A is a substance which occurs either in such animal foods as milk, butter, liver and cod-liver oil, or as a similar substance with vitamin A-activity in carrots and green vegetables. During the period of World War II, when the use of every acre of land in the British Isles was planned to give the maximum yield of nourishment, elaborate calculations were made of the yield of vitamin A per acre for every type of crop. At the top of the list came carrots, producing 1,800 million international units of vitamin A per acre; next were hot-house tomatoes with 820 million international units per acre of glass; cabbage followed at 60 millions; Brussel sprouts, which are extravagant of land, at 10 millions; and, at the bottom of a long list, came onions at little more than zero. The moral of this table was not overlooked. The acreage of carrots was increased, their production subsidised and every device of publicity exploited to insure their consumption. As for tomatoes, every commercial grower of flowers was compelled, on pain of extinction, to devote the major portion of his glass-houses to tomato-growing.

Now nutrition is always important, and in a siege becomes a paramount consideration. But even in the Britain of World War II, picturesquely described as besieged, nutritional needs could not wholly over-ride other factors in the choice of diet. Onions, it is true, possess no known nutritional advantages, and no scientific nutritionist has ever been able to find a pretext for recommending them, although several of the wiser experts have suggested that some day one will be discovered. Similarly, no authority has attributed any great nutritional value to pickles or sauces. In peace time, these are regarded as desirable adjuncts to meals of cold meats and particularly so when people are indulging in snacks at the bar. It might have been expected that sauces and pickles could be dispensed with in war time, but the contrary seems to be the case. Pickles are needed by the Army, the Navy, the Air Force and the general public in time of stress seemingly in quantities much in excess of those normally enjoyed. Perhaps they give a zest to the duller meals.

This appreciation of pickles and sauces in war time brought an unexpected burden to the vegetable programme of Great Britain, which had been planned on a nutritional basis. Land had to be found to supply the pickle crop, several thousand acres were needed for planting 'pickling' onions and garlic, more than a thousand acres for 'pickling' cauliflower, eleven thousand acres for mustard and sizeable areas for gherkins and red cabbage.

Similarly, such vegetables as asparagus, marrow, sea-kale, celery and even rhubarb are treated by the scientific dietition with contempt. Have these vegetables any value? Asparagus is appreciated by the gourmet for its elusive flavour rather than for any nutritive factor. Certain sophisticated people insist that asparagus is the only vegetable worth eating, and growers never have difficulty in finding purchasers for their product. Sea-kale and celery are regarded as vegetables fit for the gods and, unlike the nutritious cabbage or carrot, are eaten with real relish, yet their nutritive value is low.

We began this chapter by saying that people eat vegetables because they like them, or because they are accustomed to them, and occasionally because they are hungry. It may be that these still remain the most powerful reasons. Be that as it may, a further and most modern reason has intruded throughout our discussion; it is, that sometimes people eat vegetables because they believe that they are good for them.

Green vegetables are highly perishable. For this reason, the technology of handling them is very different from the manufacture of flour or sugar, or even from the distribution of meat. The extreme perishability of vegetables, together with their direct dependence on weather, produces the fluctuations in price and supply upon which it is the delight of economists to pass comment and which government departments defy at their peril. At present, no practical technical method exists for preserving green vegetables which were destined for sale fresh, but which remain unsold at the market.

The structure of green leaves consists fundamentally of a 'brick wall' of cells. These cells, however, are not rigid like bricks, they can more aptly be compared with elongated balloons which only maintain their shape and stiffness so long as they are well blown up. After a cabbage is cut, the cells of which its leaves are composed only remain 'well blown up' for a comparatively short time before they begin to wilt. The cells of a plant remain alive for some time after it is plucked. That is to say, each cell retains intact its many enzymes by means of which it utilises nutrients and derives the energy for life. In due course, if it is sufficiently disturbed, either by dehydration or mechanical damage or other means, the cell dies. We are scientifically correct when we look at the flowers on the mantelpiece and say that they are 'dead'.

Among the enzymes in the cells of a cabbage leaf can be numbered a compound of vitamin C. Thus an analysis of vitamin C, which is comparatively easy to do, will give us at the same time our measure of the loss of life of the vegetable, that is to say its freshness, as well as its nutritive value. A certain investigation reported in the technical literature showed that cabbages bought at random at a cheap market contained as much vitamin C as cabbages freshly harvested, whereas those purchased from an expensive shop contained less than 40 per cent. This means that the first cabbage *did* taste as good as one from one's own garden, whereas the second had lost half of its nutritive value and with it, almost certainly, much of its flavour of freshness. In other words, the varying quality of bought vegetables depends on the speed with which they are brought to market, the care with which they are handled and their original state when harvested.

The same scientific authority, who found a loss of more than 60 per cent. of vitamin from shop cabbage, also reported a loss of 50 per cent. of the vitamin C from cauliflower, offered for sale this time at the cheap market, whereas that sold at the expensive shop contained as much as one freshly harvested. Similarly, cheap French beans were found with 60 per cent. of their vitamin C remaining, and expensive French beans with only 43 per cent. On the other hand, expensive green peas had retained almost 50 per cent., compared with 35 per cent. in the less expensive sorts; whereas Brussel sprouts bought in cheap and luxury quarters alike contained equally about half what might be expected from the fresh vegetable.

Very different from the green vegetables, which lose their quality, flavour and nutritional value all together as their cells die from dehydration, wilting or bruising, is the potato. Whereas green vegetables cannot be stored at all in their fresh form, potatoes, from the very nature of their cultural habits, are always stored from the time they are harvested until the harvest the following year. It has already been mentioned that it is potatoes rather than green vegetables which in truth protect the modern British population from ill-health due to vitamin C deficiency.

The nutritive value and culinary quality of the green vegetables purchased in a great city depend on the manner in which they have been handled and the expedition with which they have been brought to market. The vitamin C content of potatoes, on the other hand, is almost entirely a matter of the calendar; within reason, nothing that the people handling the potatoes can do affects it materially in any way. In December, a potato contains approximately three-quarters of the vitamin C it possessed when dug in October or November. By January or February, it contains about half, and from March onwards about a quarter of the original concentration.

The basic technology of potato storage has not changed in the last three hundred years. Potatoes are stored either by not digging them, or, more commonly in these modern days, by burying them again in 'clamps' after they are dug. The principal technical requirement is that they should be protected against frost.

We shall come presently to the modern development of technology leading to the 'dehydrated potato' of World War II. Meanwhile it is salutary to refer to the scholarly works of Dr. Redcliffe Salaman, who has pointed out that the local inhabitants of the Andes in a period certainly prior to 600 A.D. had discovered a means of preserving the potato by alternate freezing and drying. The final product, known as 'chuno', could be kept for an indefinite period. Dr. Salaman reports that 'chuno', indistinguishable in appearance and taste from that still made today, is found in the tombs of the pre-Inca settlements along the Pacific Coast. 'It is,' he writes, 'probably man's earliest and most successful discovery in the realm of food preservation.'

Potatoes are more than a source of dietary vitamin C. They are also a farinaceous food, contributing carbohydrate and hence calories. About 80 per cent. of their dry weight consists of starch; another 5 per cent. is sugar. They also provide a by no means negligible contribution of protein, averaging 8 per cent., most of which is of high nutritive value. Indeed, if a working man is prepared to eat 14 lbs. of potatoes a day, he need only drink a daily pint of milk as well to obtain an adequate and balanced diet.

This remarkable completeness of potatoes, although it has raised them up in the eyes of the scientific priesthood, has depressed them in the estimation of the civilised anthropologist. Their cheapness, and the ease with which they may be grown, depresses the human status of peoples who come to depend on them for food. The civilised man uses them as a source of vitamin C and as an agreeable secondary food of neutral flavour capable of being eaten with pleasure every day.

As we have already remarked, the potato looks after itself. so well that the modern food technologist cannot lay claim to any major development. For example, although a great deal of scientific effort was given to the development of dehydrated potatoes during World War II, they cannot be considered to have established themselves as a major foodstuff, nor is the scientific control over their quality by any means complete. The principles of potato dehydration are, firstly, the rapid scalding or cooking of the potatoes to destroy the cellular enzymes which, like the mainspring of a watch which is being taken apart, would cause a rapid chemical breakdown of the cellular contents when the integrity of the cell itself was disrupted during drying. The stabilising effect of scalding is enhanced if a small concentration of sodium sulphite is dissolved in the scalding water. After they are scalded, the potatoes are dried in a current of hot air.

Dehydrated potatoes possess many important advantages. They are stable, and only need to be mixed with hot water to become something barely distinguishable from mashed, boiled potatoes. Their usefulness for campaigning troops, explorers and others who are existing at the lowest human standards consistent with life are therefore undeniable. As an article of diet for civilised men they possess two disadvantages compared with fresh potatoes cooked on the spot. In the first place, just as dehydrated fish can only be reconstructed into the sort of fish found in fish-cakes, dehydrated potatoes can only be reconstituted into mashed potato. This is perhaps only a minor drawback. Many people like mashed potatoes, and they can be used as ingredients of many dishes.

The second weakness of dehydrated potatoes is, at the time these words are written, a more substantial one. It is not always possible to produce a dried material which, when reconstituted, has a flavour, colour or consistency as good as that of 'real' potato. The flavour may differ from that of fresh potato only by the merest *nuance* or, on the other hand, it may be downright nasty. The colour can easily be affected if one or other of the cellular enzymes of the potato has survived heat treatment—the blackening of a cut raw potato is probably the best-known of all enzyme reactions. There are also, however, many other factors—for instance, the chemical composition of the soil in which the vegetables were grown—which affect colour.

Consistency in dehydrated potatoes is important. Sometimes when they are reconstituted, they form a slimy, sticky mass, while on other occasions their consistency is almost identical with fresh cooked and mashed potato. Since the principal available method of scientific control is to taste and touch the material produced after it has been manufactured, it sometimes happens that dehydrated potato on the market is less good than freshly cooked potato.

Dr. Redcliffe Salaman has held that the very nutritive excellence of potatoes is a big factor in depressing human living standards. Because a man can grow enough potatoes to fill his belly at little cost either of money or labour, and can sustain himself in health thereon, much of the motive force for raising himself higher has disappeared from life. Although the modern dehydrated potato powder can claim some small measure of appeal to the palate, its principal function also is nutritional. It is interesting, therefore, to turn at this juncture to a form of processed potato developed during modern years, the purpose of which is frivolous rather than nutritional. I refer to potato 'crisps'.

A great deal of technical effort has been devoted to the manufacture of 'crisps'. Firstly, a special variety of potatoes is always selected by the manufacturer suitable both for frying without waste of oil and of a consistency suitable for slicing. The potatoes are treated in a revolving drum lined with carborundum which rubs off the peel. They are then passed through a slicer which cuts them into uniform sections one thirty-second of an inch thick. After they are cut, the slices are washed under high-pressure jets to remove some of the starch which might cause them to stick together during frying if it were left in. Next, surplus water is removed in a centrifugal machine. The slices are then fried. Manufacturers attach much importance to the exact details of frying. The thin 'crisps' are very quickly cooked. One specification, for example, calls for 210 seconds immersion in oil at 300° F.; it is claimed that a few seconds too long will ruin the batch. After they have been fried, the 'crisps' are spun round in another centrifugal machine in order to shake off the surplus oil and are then weighed and packed, often entirely by means of automatic machines of great complexity.

The phenomenon of the potato 'crisp' is one of considerable anthropological interest. Its appearance can only be interpreted as a sign of wealth. When a member of the community used to buy a pennyworth of 'chips', he or she was buying in the form of hot, fried potato a cheap and substantial contribution of energy and a material amount of vitamin C. Today, when the same individual buys a packet of 'crisps', he or she is contributing three pence to the maintenance of a number of complex machines and the upkeep of a modern factory. The purchaser is buying a negligible amount of food, but he is acquiring a modest gastronomic embellishment.

Peas are a vegetable to which the art of technological science has been applied in several ways; they can be eaten as two quite different types of food. Green peas contain 85 per cent. of moisture. This is a good deal less than the 94 per cent. present in cabbage; but they can, nevertheless, be classified as a green vegetable, the principal nutritional function of which is to contribute vitamin C and vitamin A-activity to the diet, while their most important gastronomic significance is to add freshness and flavour to a meal. The best guidance that scientific knowledge can contribute to the distributor is to purchase his peas as fresh as possible and transport them to the market as quickly and with as little damage as he can.

Green peas, it is hardly necessary to state, are peas harvested in an immature state. When they are allowed to ripen, their water content becomes reduced and their vitamin C content gradually dwindles to nothing. At the same time their protein and their calories increase. Indeed, a dish such as peas pudding is a solid source of energy calculated to fill a hungry belly, and in colloquial terms is not a 'vegetable' at all. Because dried peas are durable and need not, therefore, be grown for rapid transport to a fickle market, they are cheaper than green peas. It is, therefore, no matter for surprise that because they can roughly be disguised to simulate green peas to the ignorant and untrained eye of the general, a substantial industry has developed to manufacture these greened peas.

There is no direct deception in the matter. A working-class housewife has only to consult the Food Standards and Labelling

Regulations of the Ministry of Food and the Department's Manual of Nutrition (H.M.S.O., price 1*s*.) to discover that she is giving her family something with none of the health-giving properties and vitamin content of fresh peas when she buys a tin legally labelled 'processed peas'. Even though the similarity is too tenuous to deceive any palate laying claim to a vestige of discrimination, the fact remains that the manufacturers of processed peas take considerable pains to imitate as many as they can of the features of green peas.

It is a complex business to manufacture 'processed' peas. First, the dried peas have to be washed free from extraneous matter, earth and other dirt. Next they are sifted. They are then passed slowly along a travelling belt which eventually brings them into the orbit of a revolving drum studded with sharp, bent needles. This drum picks up the peas which contain worm holes and allows the sound ones to pass to the steam cookers. After the peas are cooked, they are dyed green, packed in cans, sterilised and sealed.

These peas are a wholesome food. The green dye used is, so far as is known, harmless and, being water-soluble, is quickly excreted from the body. The peas themselves provide calories and protein, but they are entirely lacking in vitamin C and vitamin A and for that reason do not come into the same dietary category as fresh vegetables. Because fresh vegetables play rather a special nutritional role in the diet (as vehicles of vitamin A and C, that is to say), it is perhaps unfortunate that the manufacturers of 'processed' peas should have chosen to imitate green peas in the colouring and presentation of their product. 'Baked beans', for example, which are similar dietetically to 'processed' peas, stand firmly on their own feet as a justly popular and distinctive article of diet. They also provide calories and protein. And their manufacturers make no pretence that they are anything other than what they are.

The official attitude to 'processed' peas in Great Britain is a minor paradox. The conscience of the Ministry of Food is so tender on matters of truth that it was only after a struggle that the famous sherry, 'Bristol milk', was allowed to retain its centuries-old title. Yet, although 'processed' peas look like green peas and many people believe that they are dietetically equivalent to green peas, whereas they may contribute to actual impoverishment of the diet by being used as a substitute for a green vegetable, no objection is made to them because their description, 'processed', is not untrue, but only meaningless.

Dried peas, together with dried beans and lentils, present few problems to the food technologist. Once they are dry, they are highly stable and, provided they are protected from moisture and vermin, can be kept almost indefinitely. They can, of course, by no means be considered as fresh vegetables.

Although such vegetables as cabbages and carrots have been preserved by drying since the earliest times, in the past the culinary quality and especially the anti-scorbutic activity of the vitamin C in the dried article has been poor. During the years of World War II, renewed scientific interest in Germany, the United States and Great Britain produced the key to the problem. As in the case of potatoes, it was discovered that if the vegetables were scalded before being dried, the inactivation of the enzymes in the plant cells by the heat of scalding allowed the subsequent drying to be done without changing the green colour of green vegetables and without ruinous loss of vitamin C. Two contributions to the technique of drying were made by British investigators at Cambridge. First, it was discovered that the addition of sodium sulphite to the scalding water assisted the retention of colour and incidentally of vitamin C; and secondly, it was found that if a series of batches were scalded in the same water, loss of vitamin C was still further minimised. In actual fact, the loss of vitamin C is about the same if a fresh cabbage is cooked in a domestic kitchen or if it is 'dehydrated' by the most modern methods in a factory and then reconstituted by the addition of hot water.

Vegetables are comparatively cheap and 'dehydration' is comparatively expensive. The advantage to be gained from 'dehydration' is durability. Unfortunately, 'dehydrated' vegetables are not altogether easy to store. To start with, they must be protected from moisture by being packed in tins. Secondly, their quality is affected by oxygen and it is therefore advisable to exhaust the tins of air and refill them with an inert gas such as nitrogen. When these precautions are taken, dehydrated vegetables retain their quality for about eighteen months. If 'dehydration' could be used to preserve a seasonal glut of vegetables and to solve the difficulties of transport and distribution, which is one of the principal problems of the vegetable production industry, it would be an important technical advance. The reduction in weight is also a useful achievement. Unfortunately, overbalancing the economic advantages of stability and weight reduction are the economic disadvantages of the cost of dehydrating plant, of fuel for drying and of tinplate for storage.

Food has been preserved by freezing for a very long time. However, it is not possible to preserve vegetables by simply freezing them. The expansion of the ice breaks up the structure of their cells and, as we have said before, when this happens the cellular enzymes very quickly bring about the breakdown of the normal chemical structure and the vegetable is spoilt. About 1918 the first promising trials of quick-freezing were carried out, and within the last twenty years a substantial quick-freezing industry has developed, principally in the United States but also in Great Britain and European countries as well. The technical principles are the same as those governing drying. Vegetables must first be subjected to a scalding process to inactivate the enzymes, then they can safely be frozen and, so long as they are kept frozen, they can be preserved almost indefinitely.

The most popular frozen vegetables are peas. Reputable manufacturers take great pains to select peas of good quality and to process them as quickly as they can after they are harvested, often arranging special transport between the fields and the factory. The flavour of frozen green peas is nearer to that of fresh peas than that of peas processed in any other manner. Thus, this new technical procedure does solve the basic problem of distributing a perishable food to a large urban community. Unfortunately, once again the basic economics of the process are obscure. Frozen peas are a useful luxury—that is, a fresh food out of season. But just because the season for peas is short, the freezing firms must look about for other crops to carry them through the year. Broad beans are a crop which can be successfully frozen. In the United States, the powers of publicity have enabled frozen spinach to be marketed. It is, however, doubtful whether frozen spinach has any advantage over fresh spinach, and the demand for out-of-season spinach as a luxury cannot be overwhelming.

Because the process of quick freezing involves a preliminary scalding, which causes some loss of nutritive value, followed by a further slow loss during the course of storage, the final product appearing on the plate possesses a vitamin content closely similar to that resulting from the domestic cooking of the fresh vegetable.

The commonest technical method of preserving vegetables is canning and it is interesting once again to find that the losses of nutritional value occurring during the process of canning are approximately equal to those taking place in domestic cooking and lead to a product no better and no worse than a fresh cooked vegetable.

Loss of nutritive value of vegetables used for canning may take place at three stages of the process from the field, through the cannery, to the dining table. The first stage is the period between harvesting the vegetable and its arrival at the factory. This is usually lower for a canner than for a housewife, because the canner, like the quick-freezer, usually takes special steps to transport the crop he buys quickly and directly to his factory, and so avoids much of the waste from spoilage which may occur in normal distribution to the market, the shop and the home—a process which may occupy several days. The second stage during which loss occurs is during the passage through the cannery. For fresh peas, this may amount to as much as 70 per cent. of the purchased weight. The amount of non-edible material removed in peeling, trimming or removing pods is about the same as in a well-regulated kitchen, but at the cannery waste material may be put to good use by being converted into silage for livestock, by being returned to the land as manure, or by being dried as cattle food.

The worst loss of nutritional value in canning is occasioned during the process of 'blanching'. Vegetables entering a cannery are first washed in cold water to remove adhering dirt. They are then 'blanched' by being heated in water at boiling point, or a little lower, for from two to twenty minutes. The purpose of 'blanching' is five-fold. It acts as a cleansing operation; it causes the vegetables to shrink; it often improves the colour; it expels entrapped air; and, above all, it destroys the cellular enzymes and thus, as in freezing, prevents subsequent deterioration. Unfortunately, it takes about 25 per cent. of the sugars and mineral substances out of such vegetables as peas, and causes a loss of 10 to 25 per cent. of the protein and up to half the vitamin C. It should be repeated that these losses are no greater than those occurring during domestic cooking. Nevertheless, it is a challenge that the technologist has not so far met—that no better can be done under the controlled conditions of a modern factory process.

The actual sterilisation of the filled cans of vegetables, which is done by raising the temperature to from 116° C. to 127° C., does little harm to the food value of the product because it is a process carried out in the absence of air. With baked beans there is a destruction of about 20 to 40 per cent. of the vitamin B_1.

The third stage during which loss of the food value of canned vegetables may occur is probably least important. It is during storage of the canned material. Most canned foods can be kept for several years without undergoing significant change. There is in some instances a change in the distribution of nutrients between the solid and the liquid fractions in the can and, in those articles where the liquid is thrown away, a loss of food material will occur.

At the outset of our discussion of vegetables, we reviewed their significance for health. It can easily be seen that a certain proportion of fresh vegetables or fruit must be included in a diet if health is to be maintained. For this reason, if the amount of vegetables in a diet is low, it is wise for the cook to listen to the dietitian. She should refrain from 'keeping them hot'. She should avoid allowing their enzymes to break loose, as happens if cooking is started in cold water instead of in boiling water, which destroys the enzymes instantly. And she should eschew cooking vegetables twice. All of these practices lead to loss of vitamin C. The evidence available at present, however, suggests that some of the emphasis on the 'health giving' aspects of vegetables has been overdone. Provided people get the comparatively modest amounts of potato and vegetable needed to supply the vitamin requirement, vegetables can best be treated on their culinary merits. And on their culinary merits onions and pickles and asparagus and garlic all have a place in the diet, in spite of their failure to qualify at a scientific examination.

To sum up. Vegetables are comparatively cheap. They are also, with certain exceptions, highly perishable. It is inevitable, therefore, that the technician should have attempted to overcome their perishability. He has done this in three principal ways. First, canning gives us peas and beans, for example, not dissimilar in quality from fresh peas and beans. On the other hand, canning can also be said to have given us the dubious present of 'processed' peas. Canned vegetables possess several valuable characteristics. They are durable, easily stored and easily transported. When manufactured to a good standard of quality, and when presented honestly on their own merits and not disguised as something they are not, they can stand up reasonably well in flavour and appearance to fresh vegetables. As with so many processed foods, however, canned vegetables must often lose the structure that, be it in a cabbage, a carrot or a cauliflower, is one of the attractions of the fresh material. That is one of the reasons why canned fresh peas, whose small size allows them to retain their structure, are so successful. Finally, it can be said without reservation that, so far as is known at present, the nutritional value of canned vegetables differs little if at all from vegetables which have undergone the equal losses occasioned by domestic cooking.

Next comes dehydration, an interesting *tour de force* which is also capable of producing a product of equal nutritional value to that from which it was derived. It saves weight and space, in as much as a tin of dehydrated potato is smaller and lighter than would be the tin needed to contain the equivalent amount of canned potato. With dehydration, however, it is not yet always possible to say that the processed article is as agreeable in flavour as it was when fresh. The *gourmet* can also criticise dehydration as a further branch of food technology exemplifying the modern trend of urban Anglo-Saxon food handling towards the reduction of all diet to a mush. Dehydrated potato can only be restored to mashed potato just as dehydrated egg can only reassume the consistency of scrambled egg. The nutritionally perfect experimental diet in the laboratory is usually a smooth powder, and one day the nutritionally perfect human diet may be the same.

Frozen vegetables—to complete our list—cannot be subjected to the same criticism as that made of dehydrated ones. Indeed, because they are a luxury requiring to be specially prepared and packed, and capable of survival only in the artificial environment of a specially constructed refrigerator, their face is very much their fortune. That is to say, their appearance, taste, structure and consistency must be as close to that of the good quality fresh product as possible if it is to be worth while expending so much technical skill in preserving them for use out of season.

11

Fruit and Modern Jam

The hardest blow which fruit has had to bear in the modern world has been the neglect of the scientific nutritionist. The dietitian, at least in Great Britain, has interpreted scientific facts to mean that fruit, with the exception of oranges and blackcurrants, is merely a luxury and is unnecessary for the 'optimally balanced' diet. Scientific administrators have not said in so many words that an apple a day does *not* keep the doctor away, but neither have they lent the weight of their prestige to the proposition that it does.

To the nutritional expert the only pretext which appears valid for including fruit in the diet is the fact that it contains vitamin C. In the United States, where large quantities of oranges are produced, a custom was developed by the orange growers, supported by what is now recognised to be a mistaken notion of the amount of vitamin C required for health, that all human diets ought to include a glass of orange juice at breakfast. Leaving aside the fact that large healthy sections of the human race never eat oranges, it is agreed today, as we have seen in our discussion of vegetables, that all the vitamin C required for well-being can be obtained with little trouble from potatoes and vegetables, quite apart from fruit. It can be seen, therefore, that the purely clinical justification for fruit is somewhat tenuous.

All this scientific talk, however, is as beside the mark as it was in the instance of onions and asparagus, if we propose to discuss fruit as an agreeable foodstuff rather than as a prophylactic. The second tribe of scientists, those concerned with technology and not with nutrition, have recognised that fruit is indeed an agreeable article of diet and have achieved much ingenious success in modifying its natural characteristics, in preserving it and in transporting it half way round the world.

Today, apples can be brought to Great Britain from New Zealand and from Canada, fruit juice and tomato juice from Australia and all manner of fruit, ranging from grapes to oranges, from South Africa. Indeed, before 1939, British imports of fruit accounted for 35 per cent. of all the oranges grown for export and 45 per cent. of all other exported fruits.

The variety of fruit available throughout the year to a modern civilised community is, more than any other type of foodstuff, almost entirely due to modern science and technology. For example, the banana was familiar to the armies of Alexander the Great when they were in India in 327 B.C. Arab traders eventually spread the growing of bananas across Africa to the Guinea coast from whence the Portuguese in 1482 took them to the Canary Islands. They were transported to the West Indies by the Spaniards in 1516 and from thence reached the South American continent. But they were unknown in Europe, except as an exotic rarity, until about 1890 simply because no technical method had been achieved for transporting them.

The secret which today allows bananas to be sold in Britain and other temperate countries is the knowledge that they cannot tolerate a temperature below 55° F. If unripe bananas are exposed in a cold draught in a greengrocer's shop on a wintry day, even for a short time, they become chilled, their skin becomes a muddy, khaki colour, they fail to ripen and are uneatable. Today, unripe bananas are kept at an even temperature throughout their journey on sea and on land, and even in the larger shops they are stored in warm 'banana rooms'. Under this treatment they ripen steadily up to the time they are eaten.

The scientist has not been entirely successful in his handling of bananas, although his solution of the problem of transport was remarkable and complete. The import of bananas into Great Britain rose steadily from about two million bunches in 1900 to over twenty-two million bunches in 1937, and, in parallel with this enormous increase, a larger and larger proportion of the total crop was grown in the Island of Jamaica. Furthermore, almost the entire trade consisted of a variety called Gros Michel.

Standardisation and uniformity are excellent virtues, but they may lead to danger. The danger which has today overwhelmed Gros Michel bananas is 'Panama disease'. Forty years ago, this disease affected a patch of about two acres in a banana plantation in Jamaica. By 1931, more than fifteen thousand acres of bananas were involved. Gros Michel bananas were doomed, and all the botanists could do was to suggest the replenishment of the plantations with a different variety which would be resistant to the disease. Meanwhile the exportable banana crop from Jamaica, which amounted to twenty million bunches in 1939, fell to six million bunches in 1949.

Oranges are tougher characters than bananas; yet, even so, scientific knowledge has markedly facilitated their arrival into temperate countries. The botanist was first on the scene. Thanks to him, the element of hazard, which only speculative consumers enjoyed when peeling an orange which might be sour or sweet, or yellow or red, has been reduced; his efforts now enable the producer to market a standard article which, as a general rule, is of high quality.

The two principal varieties of oranges found on the market today are the sour Valencia oranges from Spain, which are commonly used for marmalade, and the sweeter Jaffa oranges. The latter type, although agreeable to eat, are highly subject to rot. This rotting is principally due to a mould, *Penicillium digitatum.* Mould spores occur naturally on the skin of the fruit while it is on the tree. Thus it happens that all oranges are infected more or less with mould. Not all the fruit by any means, however, become rotten; only those which are susceptible.

A great deal of work has been done in studying the factors which control the susceptibility of oranges to rot. Obviously, the most important is the number of infecting spores. If the number acquired in the orchard is large, if the fruit pick up additional infection from the boxes and baskets in which they are placed, and if they rub shoulders with heavily infected neighbours during grading and storage, the probability of mould gaining entry and hence causing rottenness is increased. A further factor is temperature. If the temperature is over, say, 85° F., rot will never occur, but at this high temperature the flavour will soon be spoiled. On the other hand, at moderate temperatures oranges resist mould infection best if they are kept cool. Yet another factor is moisture: oranges keep better in a dry atmosphere.

Most important of all, from a practical standpoint, is freedom from mechanical damage. Clearly, if the skin is punctured or otherwise broken, mould will gain access and the orange will rot. For this reason, great care is taken in picking oranges to ensure that the pickers have short finger-nails and handle the fruit carefully. Similarly, a knowledgeable fruiterer will refuse to buy a box of oranges with a broken side because he knows that there is a good likelihood that some of the fruit will have been injured, mould will have grown in them, and not only will the damaged oranges have developed incipient rottenness but they will probably have raised the susceptibility of the others by disseminating mould spores around them.

In spite of taking all possible steps to increase resistance to infection, and in spite of such good house-keeping measures as the scrupulous cleaning of baskets and equipment, orange growers are unable to prevent their fruit from being surrounded by mould spores. They are also unable to prevent a proportion of them falling victim to infection by these spores. That being so, they have turned to the technologist for a method of destroying the mould which has proved to be inseparable from the oranges.

As long ago as 1934, it was suggested that the best method of destroying the moulds naturally occurring on the skin of oranges was to wrap the fruit individually in paper impregnated with an antiseptic. The first substance to be tried on any scale was iodine. Although iodine-treated papers were found to be effective, a number of objections prevented their general use. The treated papers were unsightly and stained the wood of the boxes used for packing. Furthermore, the large-scale preparation of these wrappings was found to be very difficult. The fact that the use of iodine in this way contravened the Public Health (Preservatives in Food) Regulations was an added deterrent.

After a long chemical investigation the substance, diphenyl, was hit upon as the best antiseptic for orange wrapping papers. It has a characteristic smell, which is not universally popular, but, although this smell is taken up by the peel, it does not affect the flesh. Diphenyl is remarkably effective in preventing mould damage. Before it was employed, 17 to 20 per cent. of all Jaffa orange imported into Great Britain were, on an average throughout the season, found to be rotten. Only 2 to 4 per cent. of oranges shipped with wrappings of diphenyl-impregnated paper rotted. Here, then, we have a further example of an important technological advance. The advantage derived from diphenyl is very clear. A reduction of 15 per cent. in losses from the twenty million cases of oranges imported into pre-war Britain represents three million cases.

The objections to the use of this chemical are, at the present time, vague and unsubstantial but nevertheless important because they are objections of principle. Diphenyl is not known to be markedly toxic, yet no one would willingly consume it in a food. It is true that no harm clearly attributable to the use of this chemical has been proved, that the skin of oranges is not generally eaten except when the oranges are turned into marmalade, and that the amount of diphenyl picked up by a single orange is not very great. Nevertheless, we have here a further example of yet another chemical substance added, with the best motives in the world, to a foodstuff. Many public health authorities are uneasy at the increasing number of such substances.

The use of a chemical agent, such as diphenyl, to arrest mould infection and hence rotting, is relatively a less important scientific contribution than the proper management of temperature. Fruit is a living thing, and the changes which occur within the fruit itself are of greater significance than the changes brought about by an outside agency such as an intruding mould. Temperature affects the life processes of the plant. As we have already seen, warm temperature is essential to the ripening of bananas. South African plums, peaches and pears, like bananas, also suffer irreparable harm if their temperature is allowed to fall below, say, 55° F. If these fruits can be maintained at 60° F. to 65° F., when they arrive at their destination in a temperate climate they will ripen naturally and keep well. Other fruit, notably apples, can be kept for longer periods by cool storage than would otherwise be possible. The temperature usually employed is just above freezing point. This treatment allows some varieties of apples to subsist from September until March. Others will only keep until about the end of January when controlled low temperature alone is employed as preservative agent. The scientific technologist, however, has some other cards up his sleeve.

Fruit, as I have said, is a living thing. The cells of the fruit, like those of other living organisms, maintain themselves alive by a process of respiration. That is to say, they absorb oxygen from the air and themselves give off carbon dioxide. It has been found that when the amount of oxygen in the air in which fruit is stored is reduced and the amount of carbon dioxide correspondingly increased, the rate of respiration is slowed down and the fruit keeps for a longer period. These conditions are achieved by storing apples or pears, which are most commonly handled by this treatment, in a gas-proof room. Fans are installed to circulate the atmosphere through the boxes of fruit, so as to maintain uniform conditions throughout the chamber. Equipment is also installed to record the temperature and the concentration of oxygen and carbon dioxide at any particular time, and to allow for controlled ventilation with the outside atmosphere if necessary.

After the chamber has been filled and closed, the concentration of carbon dioxide quickly rises, as a result of the normal respiration of the fruit. Bramley's Seedling and certain other varieties of apples can of themselves achieve the optimum atmosphere for gas storage, *i.e.*, 10 per cent. of carbon dioxide and 11 per cent. of oxygen. The remainder of the space is occupied by nitrogen. Other varieties of apples and pears keep better in a mixture of 5 per cent. carbon dioxide and 2½ per cent. of oxygen. In order to achieve this, the atmosphere of the chamber has from time to time to be circulated through a 'scrubber', which is a closed tank containing caustic soda or some other chemical capable of absorbing part of the carbon dioxide produced by the fruit.

Gas storage is thus a scientific technique for delaying the ripening of fruit by making use of the products of its own respiration and hence prolonging its storage-life. A more subtle discovery of the same general character is also used commercially for *accelerating* the ripening of fruit. When ripening apples begin to turn from green to yellow, and to develop a smell characteristic of ripeness, they have been found to give off a gas, ethylene, which induces these changes in unripe fruit. This was discovered during an investigation of the reason why apples or pears stored in bulk usually ripen more rapidly than do single fruit. This was due to the ethylene gas given off by the quickest ripening individual apples or pears stimulating ripeness in the whole bulk.

Ethylene is a colourless, inflammable gas with a sweetish smell. It has a comparatively simple chemical composition and is present in coal gas and in certain natural gases found in oil-fields. It has a very remarkable effect on the ripening of fruit. For example, one part of ethylene per thousand of air is used in certain countries as standard commercial practice in ripening bananas. The ripening of a new variety, Lacatan, now appearing on the market in considerable quantities, is markedly improved by ethylene.

Tomatoes are sometimes picked either green or when just beginning to turn red. It is now common practice to ripen them at 65° F. to 70° F. in an atmosphere containing ethylene. This form of artificial ripening is also employed to increase the saleable quantities at the end of the season. The value of ethylene treatment of tomatoes is not yet fully established and, although faster ripening has been obtained in controlled experiments carried out in certain years, less satisfactory results have been recorded for other seasons.

With plums, ethylene exerts its accelerating effect. That is to say, as little as one part in one hundred and fifty thousand of air causes softening to occur more rapidly and brings on the colour change and characteristic aroma associated with ripeness. Unfortunately, with most varieties, change in flavour does not accompany the accelerated changes in appearance. Only with South African Kelsey plums does ethylene produce an unquestionable all-round improvement in complete ripening.

Ethylene brings certain advantages to people handling fruit but it also raises once again, even if in somewhat different form, the debatable question as to whether it is a technical advance altogether to be welcomed. It assists the ripening of certain varieties of fruit; and, in many instances, the artificially ripened specimens appear to differ in no way from those naturally matured. In other instances, undesirable effects occur. These effects may be nothing more than a slightly unusual appearance, but we have already referred to the plums which by colour and consistency appear to be ripe but by taste do not. Truly, as with the Greeks bearing gifts, we must treat the application of chemical science to food with reserve until it has fully justified itself.

This is not to say that ethylene has so far shown itself to be in any way harmful to health, while on the other hand, it seems capable of being of positive usefulness. As we have said, it is itself naturally produced by ripening apples. (Bramley's Seedling apples will produce as much as one hundred parts of ethylene per million in a gas store and Cox's Orange Pippins up to six hundred parts per million.) Moreover, it produces a number of valuable effects other than those we have mentioned. With oranges, besides its ripening effect, which speeds up the change of colour from green to yellow, ethylene causes them to shed their 'buttons' or stalk appendages. With oranges from some regions this reduces the incidence of stem-end rotting. A different effect produced by ethylene is the suppression of sprouting in potatoes. In a trial in which one part of ethylene in ten thousand of air was introduced, it was found that when all the potatoes not exposed to ethylene had sprouted and the sprouts had grown to a maximum length of six inches, only 2.8 per cent. of the ethylene-treated potatoes had sprouted at all, and the maximum length of the shoots was one-sixteenth of an inch. Perhaps the most interesting side-light on this important technological development is that the plant physiologists and chemists have no notion yet how so simple a compound as ethylene exerts so profound an influence on a wide variety of plants.

Fruit is available in many forms—fresh, dried, canned and, to a limited extent, frozen. In addition, there is today a considerable industry in fruit juices. Fruit pulp also is used for jam. We have already touched on some of the factors which enable fresh fruit to be transported, stored and made available for as large a part of the year as possible. Apart from the plant physiologists and chemists who have worked out the best temperature for transport and storage, and the chemists who have elaborated gas storage, treated wrapping papers, wax dips and other devices, the plant geneticist has also played his part in breeding attractive appearance and resistance to decay. These qualities have not always been obtained without sacrifice of flavour, and ungrateful middle-aged consumers may occasionally look back with regret to the remembrance of 'unimproved' trees in old domestic orchards.

In spite of all the refinements in technique which have already been discussed, the transport of fresh fruit is still often accompanied by substantial wastage, and the utmost care is required if such wastage is to be avoided. Certain achievements are still beyond the grasp of the technologist. For example, he is as yet unable to transport fresh mangoes by sea from India to England, and although he can carry fresh pineapples from South Africa to the British Isles he cannot bring them from Queensland.

Fresh fruit can, of course, be preserved in many ways. One of the oldest is by means of sulphur dioxide. Fruit which is to be used for jam-making may be placed directly into casks containing sulphur dioxide in the form of sulphite in solution. The casks of fruit thus preserved can then be used at any time to suit the convenience of the jam factory. Sulphur dioxide bleaches the colour out of fruit, particularly in the case of red fruits, but the colour is restored when the sulphur dioxide is boiled off. This is one of the advantages in the use of this chemical preservative; it can be largely eliminated by boiling. Thus jam can be made from sulphited pulp and will nevertheless fall within the permitted limit of 40 parts per million of sulphite. This limit has been increased for fruit syrups, in which British practice permits the presence of 350 parts of sulphur dioxide per million.

The modern administrator shows little apprehension about the consumption of sulphur dioxide by the public. During World War II, the British Ministry of Food, searching about for a substitute to console the housewife for the shortage of sugar to preserve her fruit, sponsored the use of tablets of sodium or potassium metabisulphite. Two of these tablets, dissolved in water in the recommended manner, produced a solution containing 1,000 parts of sulphur dioxide per million. This was sufficient to preserve fruit, and so long as the housewife boiled the fruit sufficiently before it was eaten, no danger would arise from the use of the tablets.

Fruit, like other foods, can also be preserved by drying. This is, indeed, a procedure of great antiquity. The removal of the water produces a concentration of sugar, and such dried fruits as raisins can consequently supply a substantial contribution of calories to the diet. That is to say, they can be used to satisfy hunger. At one time it was put about that raisins should be eaten as a source of iron. It is true that they contain iron, but an ounce of corned beef contains six times as much as an ounce of raisins.

A modern development in the drying of fruit has been the introduction of the process known as 'dry sulphuring'. This consists in exposing the fruit before, and sometimes during, drying to the fumes of burning sulphur. The absorbed sulphur dioxide is found to prevent a darkening in colour and avoid the development of 'burnt' flavours in such fruits as apricots and pears during storage after drying. Similarly, oxidative changes which occur in dehydrated carrot and dehydrated cabbage and give them a flavour reminiscent of hay or straw, as well as causing deterioration in colour and loss of vitamin C, can be retarded by treatment with sulphur dioxide before drying.

These technical benefits arising from the use of sulphur dioxide are considered to be of such material value that the British public health authorities have been prepared to support them by amending their preservative regulations in order to allow the sulphur dioxide-containing articles the sanction which they would not otherwise have achieved.

Besides drying, canning is also an important method of preserving fruit. It is justifiably popular. Indeed, canned pineapples and canned peaches are considered by many people to provide the highest justification for the existence of food technology at all, because they represent the introduction of a new taste to the world, a taste unknown to nature and to some opinions a taste more agreeable than that of the fresh fruits in their natural form. The technique of fruit canning presents no exceptional features different from those already described for the canning of other foods.

Similarly, deep freezing methods for fruits, which have achieved substantial popularity in the United States, present no material differences in principle from the procedure discussed earlier. The fruit is heated to destroy enzymes, sometimes treated in a sugar syrup, and then frozen. As with canning, some frozen fruits, notably strawberries, are believed by their supporters to be an improvement on the unfrozen fruit from which they are derived. On the other hand, while much frozen fruit is good, it is often not *quite* so good to eat as good fresh fruit.

The modern commercial production of fruit juices is worthy of mention. Although concentrated fruit juices are produced as flavouring agents for such confections as 'milk shakes', the major production is in this instance based on nutritional value. Orange and grapefruit juice, for example, retain almost all the vitamin C present in the original fruit. Some of the juices are canned without concentration. Much orange juice, however, is concentrated in vacuum apparatus which allows low temperatures to be used to preserve the vitamin content and the flavour.

Jam can be considered as a preparation of fruit compounded with sugar. Fundamentally, the sugar is a preservative. It is so soluble in water that the solution it forms is too strong to allow bacteria to live. The solution of salt in the Dead Sea is similarly too strong for normal fish. Thus jam is a form of preserved fruit.

In order best to preserve fruit as jam, it is necessary first to obtain good fresh fruit and then to make it into jam immediately while it still retains its full delicacy of flavour and its form and texture. Unfortunately, as soon as jam comes to be manufactured in a factory rather than made in a kitchen, the unfortunate habit which fruit possesses of ripening only in the summer becomes an obstacle to the satisfactory continuous running of a factory throughout the year. In order to overcome this difficulty, fruit pulp preserved with sulphur dioxide is employed at those times when fresh fruit is unavailable.

Manufacturers who produce a 'second best' article tend to give it a resounding name. At one time, public authorities might have deprecated such a practice as misleading to the public. During World War II, however, and thereafter, the British public authorities found themselves anxious to arrange for the production of the maximum quantity of jam in order to ameliorate the rigours of an austere national diet. It was the Ministry of Food, therefore, which firstly depreciated by law the quality of strawberry and raspberry jam by establishing 20 per cent. and 30 per cent. as the maximum amounts of fruit they might contain, compared with about 40 per cent. pre-war, and who, secondly, invented the name 'fresh fruit standard' for jam made to this depreciated quality if it was produced from fresh fruit, and 'full fruit standard' if it was artificially dyed jam manufactured from pulp preserved with sulphur dioxide.

From the point of view of nutrition and public health, jam, whether good jam, 'fresh fruit standard' or 'full fruit standard' is an unimportant item. When we consider the principles which should govern the establishment of food standards, however, we encounter once more the subtle and contradictory ethics of control. We do not know whether the production of a maximum *quantity* of jam of a somewhat inferior quality did indeed give greater dietary pleasure to a greater number than would have been achieved by a smaller quantity of good quality jam or by a diversity of jam, some good some bad. And, worst of all, we do not know whether anyone seriously thought out the question.

12

The Law and Good Food

I BEGAN this book by pointing out that, without the scientific advances of modern food technology, it would be impossible to provide the variety of food of good quality which a modern citizen expects to obtain every day as a matter of course. This is true. But what the urban dweller expects to eat is compounded of two elements—(*a*) what he needs, positively and negatively, for nutritional well-being and (*b*) what a variety of influences —education, taste, custom and availabilty—lead him to choose.

All highly developed modern States have gradually interested themselves more and more in ensuring that requirement (*a*) is met. So far as the negative side—protection from deleterious elements—is concerned, as long ago as in A.D. 1400, the use of sulphur dioxide as a food preservative was the subject of legislation in Augsburg, and its excessive addition to wine was condemned in London in 1600. But it was during the nineteenth century, coincident with the rapid advance of analytical chemistry, that the Public Analyst was established and the grosser forms of food adulteration were put down. Today, the negative approach, which merely assured the *absence* of harmful substances from food, has merged into the newer belief that the State should insist upon positive standards demanding the *presence* of minimum amounts of positively beneficial nutritional components in foodstuffs.

It was in the period of World War II that this idea came to full flower and the British Ministry of Food set out to provide a nutritionally satisfactory diet, not only to persons in the charge of the State, such as prisoners, paupers and members of the Forces of the Crown, and not only to those classes, such as expectant mothers and young children in whose welfare the modern State takes an increasingly possessive interest, but to the community as a whole. Thus the Government counted out the calories of the bread ration and insisted that the bread contained its due proportion of vitamins and calcium. Milk was distributed to infants and expectant mothers and school children according to their requirements for animal protein. Cod-liver oil and orange juice to supply the appropriate number of international units of vitamin A, vitamin D and vitamin C were provided for mothers and infants. Margarine was fortified with vitamins, dried egg was imported to supply further nutrients, vegetable crops were grown to fill the nutritional gap left by the absence of fruit, and the choice of vegetables was planned on their nutritional values.

All this was the admiration of the scientifically minded world. The population was pleased to have so much skilful trouble taken over its health, and the diet provided, assisted by the prosperity of war-time high wages, maintained a remarkable level of well-being. But it is a poor thing if the wealth and knowledge of modern progress is to lead only to the 'adequate' diet of an experimental laboratory. Civilised man demands something more from his food than that.

This is not to say that the State intervention in modern food technology has not achieved remarkable good. For instance, the Food and Drugs Act of 1938 lays down that it is an offence for any person to sell or offer or expose for sale or have in his possession for the purpose of sale any food intended for, but unfit for, human consumption. This Act goes into considerable detail in its provisions for ensuring that food that is to be sold shall be sound. For example, rooms in which food is prepared for sale must not contain or communicate directly with a lavatory, dustbin or ashpit. Water used in such rooms must not come from a cistern communicating with a lavatory. Rooms where food is prepared must be kept in good repair and may not be used for sleeping in. If a room is used for the manufacture of ice cream or sausages or potted meat and the like, it must be registered. There are special regulations in the Act calling for the regulation of dairymen, the inspection of dairies and of the people working in them and of the churns and utensils they use. People manufacturing artificial cream must also be registered and their activities must conform to a number of rules. Similarly, the Act takes a detailed interest in margarine manufacturers, whose premises must also be registered.

Food must, as laid down by the Food and Drugs Act, be free from harmful substances. Among such harmful materials, arsenic is the most outstanding. In 1900, over six thousand people were poisoned by beer made in Lancashire and Staffordshire from glucose contaminated with arsenic. The beer contained from 5 to 15 parts of arsenic per million. This outbreak of arsenical poisoning, in which seventy people died, focussed attention on the problem. When the matter was investigated, it appeared that mild arsenical intoxication had been prevalent in the Manchester area for many years before 1900 but had been mistaken for alcoholic neuritis.

The report published in 1903 of a Royal Commission set up under the chairmanship of Lord Kelvin to investigate the poisoning due to beer, contained recommendations which have stood to this day. The principal proposal, which has been generally followed although it has no statutory force, was that solid foods should not contain more than 1·4 parts per million of arsenious oxide and that liquid foods should not contain more than 0·14 parts per million. The difference between the limits suggested for solid and liquid foods is based, firstly, on the assumption that more by weight of a liquid is consumed than of a solid food and, secondly, that the arsenic in liquid is more readily absorbed than in solid.

Whether this is generally so or not, it is perfectly true that arsenic in fish is not easily absorbed by the body. For example, poisoning does not normally ensue after the consumption of plaice, although the normal arsenic content of this fish is 3 to 4 parts per million. The arsenic content of mussels is 120 parts per million and, strictly speaking, people ought to sign the poisons register when they buy them from the fishmongers. However, it is clear that this arsenic also is not absorbed by normal individuals.

In short, we have here the culmination of the State's interest in food from the negative basis. The Act's key points are the prohibition of the sale of food *unfit* for human consumption, or of a food to which anything has been added liable to render it *injurious* to health, or of a food the nature, substance and quality of which has been harmfully affected by the abstraction of an ingredient, or of a food, which to the *prejudice* of the purchaser, is not of the nature, substance and quality demanded.

Eight years and one war later than the Food and Drugs Act, the Labelling of Food Order, 1946, showed the first indication of a change in the governmental regulation of food from a negative to a positive approach, in which the presence of beneficial components, rather than the absence of harmful ones, was demanded. The Order, as its name implies, is primarily concerned with the labelling of packed food. Many of its regulations are admirable—for example, that the nature of a packed food should be truthfully stated on the label. Some, however, can be considered to be pedantic—for example, that, when a food is composed of many ingredients, each of them must be included on the label in the order of the proportion in which they were used. This clause leads to some remarkable and complex labels which are as incomprehensible to the public as a doctor's prescription and are scarcely conducive to humane meals. One clause at least, that excluding from control all food imported by the Government, is a piece of bureaucratic intolerance. But the interesting innovation in the Order is the regulation stating that when a food is claimed to contain vitamins or minerals, the amount of them present by weight must be stated.

In theory, the principle that the Government should regulate the quality of foods on the basis of their nutritional merits, rather than upon their freedom from dietetic demerits, is attractive. In practice, as we have seen from a number of examples, it may present so many difficulties as to put it outside the limits of wise administration. The most substantial of these difficulties is the present limited knowledge of the science of human nutrition.

This science must be a synthesis of chemistry, physiology, anthropology and psychology, together with economics and politics which are not sciences. The scientific nutritionist has just sufficient knowledge to be able to draw up a table of the amounts of calories, protein, calcium, iron and half a dozen vitamins required by *average* groups of individuals of different types. Even here, however, knowledge is not static and new observations constantly modify the details of what was known before. This information, valuable though it may be, is not suitable for dogmatic application to the composition of an individual food. The Labelling of Food Order has legislative force and it only goes so far along the *positivist* line as to require the *amount* of a vitamin which is mentioned in a label to be stated. Even this timid step is hedged round with exemptions. The wisdom of this timidity is apparent when we consider the technical objections to the more definite proposals for a fixed nutritional composition for bread, which were put forward in the White Paper on the Post-war Loaf and were discussed in Chapter 2.

The nutritional quality of any diet is the sum of the nutrients provided by all the different ingredients that go to make up that diet. Hence bread could be considered to be an unsatisfactory food in a diet composed solely of bread and jam and tea; whereas bread of the identical composition would be an excellent food if it formed a part of a general mixed diet. Knowledge exists, although it is incomplete, of what the composition of an adequate diet should be; but, unless the Government proposes to specify the *menu* to be eaten by the population, it can never be in a position to specify the precise composition of each article of diet. It, therefore, can be said that, so long as people can choose what they are going to have for dinner, the useful interference of the State in the chemical composition of each item must be restricted. Up till the present, the State in Great Britain has laid down nutritional standards for bread but not for sugar, and for margarine but not for milk.

The most rewarding aspect of the State's work in nutrition has probably been the painstaking education of mothers in the elements of baby-feeding and, most important of all, the improvement in the economic conditions of that group of the population previously known as 'the poor'.

Public education in nutrition is a subject very germane to the question of food quality. During World War I, in 1917 and 1918, the British public was exposed to considerable pressure on the subject of food. There is to be seen in the Imperial War Museum a typical picture of a housewife standing in front of a coal-fired kitchen range and gazing through the legend 'The kitchen is the key to victory: EAT LESS BREAD.' Another exhortation was designed to persuade the public to follow the self-sacrificing but ill-advised example of 'Sir Samuel Chisholm', whose daily ration, so ran the poster, consisted of a plate of porridge and two slices of bread for breakfast, macaroni and cheese for lunch, a slice of bread for tea, and soup, three ounces of meat, half a slice of bread, and rice pudding for dinner, plus tea or coffee without milk or sugar. Even in those distant days there was a poster of 'twenty-four common foods, comparing the nourishment contained in 1 lb. weight of each' in terms of moisture, calories and protein, though not mentioning the vitamins of more modern times.

When the many posters and charts used for teaching nutrition today are considered critically, they are found to fall into three distinct groups. The first is the simplest material designed to drive home a single didactic point. The British Ministry of Food has in its time produced superb examples of this type. There was the 'vegetabull', a bull drawn in terms of garden produce to teach that vegetable protein supplemented with skimmed milk or dried egg is nutritionally equivalent to meat. 'Don't forget', said an elephant holding a cabbage and with a knot in its trunk, 'green vegetables keep you fit.' A picture of a child drinking milk carried the motto 'MILK is the backbone of young Britain.' And there were many more. One of the most exotic in Anglo-Saxon eyes was a poster from Yugoslavia designed to emphasise the virtues of breast-feeding. This poster depicted a mother in high-heeled shoes and sleek black dress putting on lipstick while her infant cries in a cradle with a feeding bottle brandished in his hands. A reproving cow, feeding her calf in the orthodox manner, looks over the baby's head and remarks, in the manner of Baalam's ass, 'Why have I to feed my own and your young one as well?'

The second level of public teaching seeks to explain as well as to exhort. The first step in this approach to logic is to group foods according to their nutritional classifications. A number of methods have been used. The Americans use a diagram of a disc with seven segments, one each for (*a*) leafy green or yellow vegetables; (*b*) citrus fruit, tomatoes and cabbage; (*c*) potatoes and other vegetables and fruit; (*d*) milk, cream and ice cream; (*e*) meat, poultry, fish, eggs, dried peas and beans; (*f*) bread, flour, cereals, whole grain or 'enriched'; and, finally, (*g*) butter and fortified margarine. The chart is accompanied by a legend: 'The Basic Seven . . . eat this way every day.'

The division of foods into seven groups, as thus arranged by the publicists of nutrition in the United States, in fact represents a rough separation of the sources of (*a*) vitamin A-activity, (*b*) vitamin C, (*c*) vitamin C in lower concentration, (*d*) vitamins A and D, animal protein, calcium, fat and other milk nutrients, (*e*) animal and vegetable protein (excluding that derived from milk), (*f*) carbohydrate associated with B-vitamins and (*g*) fat accompanied by vitamins A and D.

The classification of food used for the teaching of nutrition to the public by the Canadian Council of Nutrition takes a form different from that used in the United States. It rests on 'Canada's food rules', of which there are five. The repeated slogan runs: 'These are the foods for health, eat them every day. Drink plenty of water.' And the rules are: '1. Milk—adults ½ to 1 pint, children 1½ pints to 1 quart. 2. Fruit—one serving of citrus fruit or tomatoes or their juices and one serving of other fruit. 3. Vegetables—at least one serving of potatoes, at least two servings of other vegetables, preferably leafy, green or yellow and frequently raw. 4. Cereals and bread—one serving of whole grain cereal and at least four slices of Canada Approved Vitamin B Bread (whole wheat, brown or white) with butter. 5. Meat and fish—one serving of meat, fish, poultry, or meat alternatives, such as beans, peas, nuts, eggs or cheese. Also use eggs and cheese at least three times a week each, and liver frequently.' The basis of these rules would seem to be to plan to construct a diet containing 1, protein; calcium and other milk nutrients; 2, vitamin C; 3, more vitamin C and vitamin A-activity; 4, carbohydrate and B-vitamins; and, 5, animal or vegetable protein plus such associated nutrients as iron and vitamins A and D found in liver and eggs.

In the dissemination of popular education on a subject such as nutrition, it is a difficult matter to judge how best to negotiate the blurred dividing line between propaganda and true, factual, explanation. Furthermore, the matter is made doubly difficult for the nutritionist at the early stage of teaching, before he dare try to expound the concept of nutrients as being the effective elements of foods. Considered strictly on the basis of nutritional needs, both the United States and the Canadian methods of classification have distinctly materialistic usefulness rather than general validity. There is a danger in teaching as nutrition *qua* nutrition that, for example, children must drink 1½ pints to 1 quart of cows' milk daily for health. There are large numbers of healthy children who drink less. Similarly, although it helps to ensure an adequate diet to eat each day vegetables and fruit and potatoes, ice cream, and meat, and whole grain bread, and butter, people can maintain adequate nutrition on a narrower selection of foods.

British teaching has not adopted a basic text for the nutrition education of the public. The most widely used approach has been the division of foods into three groups—body-building, protective and energy-giving. Numerous pictures, charts and posters have been designed to teach this elementary nutritional difference in the function of the different types of food. Some merely list milk, cheese, eggs, meat and fish as 'body-building' foods; milk, butter, eggs, liver and vegetables, fruit, carrots and tomatoes as 'protective' foods and so on. Others use imaginative designs and conceptions such as the 'balanced' diet, 'footsteps to health', the 'square' meal, and many others.

This type of instruction must lead to the third level of teaching if real instruction is to be given. At the third level, the material must be designed to tell, without mincing matters and without such euphemisms as 'body-building' or 'protective', something of the principles of the subject.

Nutrition, in the real sense of the word, cannot be taught by posters and leaflets. Nevertheless, much excellent material has been produced. Charts summarising experiments as to the effect of milk on the growth of rats eating synthetic diets are interesting, and can be linked to some degree at least with graphs showing the results of supplementing the diets of children. Useful diagrams are available to demonstrate the composition of foods or to show the nutritional losses occasioned during cooking. Teaching material has been produced by Government Departments for use in more serious lectures. Charts have been made available showing the relative nutritional composition of foods correlated with the relative average requirements of different groups of individuals.

Although good nutritional health can be related very closely with economic status, it is equally true that well-to-do people *can* be malnourished, either from ignorance or choice. It is reasonable, therefore, for a modern State to wish to spread a sound public understanding of the principles of nutrition so that, when the country is prosperous, the citizens shall choose to be well fed, and when times are hard, they shall understand the measures taken to balance the national diet even at the cost of changing national customs in eating. If this is accepted, there is much to be done in developing a sound general knowledge of nutrition. The number of children learning anything of nutrition at school is low, and includes a high proportion of girls. Boys learn nothing of nutrition at school; and when, in later life, they grow up into legislators, it is not surprising that they find themselves unable to grapple with the complexities of national calorie levels upon which may depend the well-being of some scores of millions of their fellow creatures.

Nutrition is vastly important to the material well-being of the State. It makes no provision, however, for the spiritual needs of a population. Just as a materialist housing policy, based entirely on 'dwelling units' and omitting any thought of cathedrals, should not be the limits of man's need, so civilised food must provide more than nutrients. It is unfortunate that the public teaching of nutrition lays little stress on elegance of presentation in meals or on good *cuisine*. Quality, in the eyes of the food planners, is partly the presence of vitamins and partly the absence of toxic substances and infection. Even the Ministry of Food's war-time recipes were largely couched on lines of 'make do'.

With their eyes perforce fixed on the adequate nutrition of the population from an exiguous food supply, the administrators in Britain found themselves by accident in trouble with food infection. Part of the trouble arose from the distribution of the food economically but, as it turned out, unhygienically in the form of communal meals served in church halls, schools and converted buildings of all sorts. Part arose from the distribution of meat, not in the extravagant form of joints and surloins and saddles of mutton but minced up as aislet, pressed beef, brawn, faggots, galantine, haslet, haggis, hog's pudding, meat paste, meat pasties, meat pies, meat roll, pressed mutton, polony, pressed pork, rissoles, cooked breakfast sausage, liver sausage, luncheon sausage, sausage roll, saveloys, pressed tongue, pressed veal, jellied veal or white pudding. These articles are all listed in the report of a Government Working Party in 1950, which pointed out that between 1945-48 and 1949 the incidence of food poisoning in England and Wales increased by 228 per cent., and that between 1941 and 1948, 47 per cent. of all cases were due to made-up meat products.

As mentioned before, although some infection may on occasion arise from such sources as an infected finger, a whitlow or a boil, it is usually caused by a failure on the part of a person working with food to wash his or her hands after going to the lavatory. Part of the susceptibility of meat products to infection from this or other sources is due to the use of gelatin—an excellent culture medium for bacteria. Meat itself, with its constantly moist surface and its rich protein composition, readily serves as acceptable soil for the growth of micro-organisms. The Working Party, besides pointing out the danger of meat products as a source of food poisoning, made a number of sensible suggestions, many of which were already officially, although not actually, enforcible under the Food and Drugs Act.

The basic difficulty of ensuring that made-up meat products, cooked meals and the like shall be safe and free from infection is that expense is entailed. For example, in a factory, the workers in the canteen are usually the lowest paid and consequently tend to include those of lowest intelligence. The supervision of such people requires the presence of a good, and consequently expensive, overseer. In the United States, food poisoning at one time reached alarming proportions, until in 1936 a lead was made by the State of Texas which devoted a great deal of attention to the problem of infection. Today hygiene is considered to be a matter of high importance. It leads to what might, under circumstances different from those in the United States, be thought of as waste, and every one of many measures adopted raises the cost of the food. This increase in cost is, however, readily accepted by the American consumer, who regards cleanliness in food shops and restaurants as something he can demand as of right because he has paid for it.

Apart from the materials used to improve hygiene, such as stainless steel equipment, space, tiles, wrapping materials, sterilising equipment, specially designed vehicles for transporting foodstuffs of different kinds, refrigeration and the rest—many of which protections are unobtainable under the austere conditions of the Old World of the second half of the twentieth century—the most fruitful direction in which advance can be made has been thought to be an attack on the innate slovenliness of the human being. With this object in view, the British Minister of Food in 1950 issued a set of 'model by-laws' which, he hinted, local authorities might enforce.

Those 'model by-laws' state:

1. Every person engaged in food handling shall observe cleanliness in regard to himself and his clothing.

2. No person knowingly suffering from or knowingly being a carrier of a disease shall handle, wrap or deliver any food so as to give rise to any risk of the spread of infection.

3. All counters, slabs and fittings shall be kept clean.

4. The food shall be protected from dust, dirt, mud, filth, dirty water, rodents, flies, insects and other sources of contamination including contamination by other persons.

5. The use of dirty paper for wrapping is prohibited.

6. Refuse shall be properly stored and carefully kept until collected.

7. There shall be sufficient light.

8. There shall be a general state of good repair.

We have in this book several times mentioned the principal cause of food poisoning, which is what is euphemistically called a failure of 'personal hygiene' and we can sympathise with the Minister's decree that 'there shall be sufficient light'. The cleanliness of the people who work in food processing plants is the basic requirement for the production of safe food. This control of the personal element, however, demands painstaking, hard administrative work.

More dramatic is the development of packaging in more and more elaborate form. The public in Britain, as elsewhere, is attracted by the idea of wrapped bread, although no harm has been proved to come from bread unwrapped. Packaging achieves its finest flower in the expansive atmosphere of the United States where, furthermore, the public is highly susceptible to the adventitious adornment of the things it buys. Thus, in the U.S., the tendency is for meat to be cut up out of sight, 'prepacked' in transparent cellulose film wrappings and displayed in glass-fronted refrigerators from which the customers help themselves. A drawback of this system is that the meat may become discoloured from exposure to light. Cheese is also offered for sale cut up and wrapped in films and foils which replace 'the wasteful rind'. Bacon is packed sliced in a vacuum container of transparent plastic film which 'prolongs shelf life'.

Let us now pass to a discussion of quality as it results from the use of modern technological processes by manufacturers. Unkind travellers from the sophisticated Old World have criticised the results of the food technologists of the United States. It has been said that mass production has taken much of the quality, using the term in its aesthetic sense, from purchased American foods. Deep freezing may officially leave the vitamins untouched but it drains away the flavour. The ingenuity of the canning industry has removed the need for any knowledge of cooking by the housewife and, it is claimed by unsympathetic visitors, food is largely tasteless when bought, and deteriorates rapidly on its journey from the refrigerator to the table.

Now quality, as assessed by the palate is subtly compounded of the taste, consistency and appearance of the food itself and partly of the environment in which it is eaten. This last factor has always made it difficult to establish absolute, objective standards of quality. Analytical composition and freedom from infection go a very long way, but they cannot altogether establish quality. Whether it be in the judging of meat, cheese, wine, apples or a loaf of bread, quality involves something more than chemical composition. In the United States, food producers sometimes attempt to provide this subtle but essential addition by means of attractive wrappings and elaborate descriptions. And here again, our unsympathetic *gourmet* from Europe feels that the stomach would not be so disappointed by a mediocre 'hamburger' if it had not been led to expect a 'Fresh, Juicy, Tender, Salisbury Steak'.

What do the food manufacturer and the modern food technologist contribute to the meals of the modern civilised man? On the debit side we can perhaps concede that some deep-frozen food is not *quite* so good as fresh food; that dehydrated potatoes and eggs do not possess the qualities of fresh potatoes and eggs; that some types of canned foods do not come up to the standards of the same foods fresh; and that standardisation and grading, valuable though they are, do deny us something. For example, how often do we see a blood orange today? Is it foolish for the old-fashioned lover of good food to feel a slight sinking of the heart at a scientific report from the State College of Home Economics of Cornell University comparing 'dielectric cookery' with 'stewpan cookery'? The report is couched in the following terms:

> The peas in this study were packed July 1, 1948, and were held

at 0° to $-10°$ until they were used December, 1948, to March, 1949. For the dielectric cooking the peas, approximately 300 grams, were cooked in the original package from the solidly frozen state. The packages were wrapped tightly in heavy brown wrapping paper and placed in a Pyrex pie plate to allow full penetration of the waves from all directions. The plate was placed in the centre of the oven, a Radarange, product of the Raytheon Manufacturing Company, Waltham, Mass. The range was operated at high speed. The peas were cooked in $3\frac{3}{4}$ mins. Another lot of peas required only 2 min. 55 secs. for the done stage. They were also cooked underdone, 2 min. 35 secs., and overdone, 3 min. 25 secs. The degree of doneness to which the peas were cooked represented extremes of acceptability for this lot of peas.

Peas cooked by each method were scored by six judges for appearance, taste, aroma, tenderness and moisture. The skins and cotyledons were judged separately for tenderness, and the appearance of each sample was determined by judging separately colour, plumpness, and glossiness of surface.

No statistically significant differences in vitamin content, or weight in frozen peas cooked in the dielectric range in their own frost and in the stewpan in 30 grams of water occurred. There was no statistically significant difference in the palatability scores. Out of a total possible score of 40 points, peas cooked by each method received an average total of 32.8. The greatest difference was in the colour and tenderness of the skins. The peas cooked in the dielectric range rated slightly superior in colour, but scored lower in tenderness of the skins. A slight undercooking or overcooking made a great difference in palatability. Overcooking resulted in a shrivelled, dull appearance and in a very hard texture.

The answer to our rhetorical question is that it *is* foolish for the person who likes a good table to oppose modern innovations in food technology as a whole. Individual developments have been found to be bad and more will doubtless occur in the future. We have instanced in this category the use of nitrogen trichloride as a flour 'improver', the employment of dulcin as a sweetening agent, and the introduction of liquid paraffin as a food ingredient. In a paper published in 1950, Dr. J. B. M. Coppock, the Director of the British Baking Industries Research Association, listed a series of newly developed chemicals used for ten different purposes by food manufacturers. Most of these have been discussed in earlier chapters. The list included emulsifying agents, stabilising agents, anti-oxidants, anti-staling agents, insecticides for paper bags, sweeteners, substances for preventing oranges from rotting, substances for preventing potatoes from sprouting and substances for preventing dough from sticking to the baking tin. Some of these may be found to be harmful but many, on the other hand, will be proved in time to be of value. This has been the way with all new developments, and those concerned with food cannot expect to be exceptions to the rule.

In general, there is no doubt that food technology, as we know it today, has been to the benefit of the modern citizen. The purist may object to the housewife with her canned food, but this same canning makes available to her articles she would not otherwise obtain. It gives her a store of food upon which she can draw. It gives her, and the traders and administrators whose duty it is to supply the dense populations of the modern world, a measure of safety against the inevitable vagaries of a transport system covering half the globe, and it enables a seasonal crop, such as peas, to be fully exploited and used throughout the year and not only at the time of harvest. Cold storage, deep freezing and dehydration all in their turn serve the same purpose.

It is natural to be suspicious of innovation, and on no subject do people entertain more profound prejudices than on food. It is easy to condemn technical advances. A striking example is the attack which was made on aluminium when it was first used for saucepans and cooking pots. It was claimed that aluminium was harmful to health, that aluminium vessels would contaminate food and damage its flavour, and that aluminium was an unnatural structural material for cooking vessels. No positive evidence was adduced. In view of the allegations raised, however, a long-drawn and comprehensive study was made into the chemistry, physiology and pharmacology of aluminium, until the objectors were eventually satisfied about its harmlessness.

Those introducing a new chemical or a new process into food technology can fairly be called upon to demonstrate its harmlessness before they are permitted to enjoy the technical benefits it provides. Most innovators nowadays are prepared to meet their obligation, although this has not always been so in the past. (A hundred and fifty years ago, for example, it was not unknown for sugar of lead (lead acetate) to be used as a sweetening agent for beer. Lead poisoning resulted among those drinking it.) By and large, the techniques used to handle the food of the crowded civilised populations of the western world today are mostly useful, sometimes essential, and seldom harmful. The major drawback of the modern, large-scale techniques is that they lead to a certain sameness.

Looking back to earlier chapters, we may recall that the treatment of flour provides a food of good keeping quality, free from dirt and other extraneous matter. The pursuit of whiteness and size in the loaf can perhaps be accepted as an amiable accidental weakness or an anthropological anomaly. The sometimes bitterly attacked white loaf of twentieth century commerce provides the calorific energy for which it is primarily consumed and, when reasonable precautions are taken in its manufacture and it is consumed as a reasonable proportion of a mixed diet, it is difficult to find evidence that people eating it are likely to obtain less vitamins than they need.

Meat technology, unlike flour technology, has seldom been accused of harming nutritional health; nor does it do so. Freezing and chilling and canning have, perhaps with justice, been accused of damaging flavour; but if the whole of a crowded population is to obtain meat, these methods of handling it must be employed. On the other hand, scientific methods of feeding livestock and handling animals immediately before slaughter enable the producer—war and cold-war exigencies apart—to give his customer the kind of joint he wants and one suited to modern conditions of domestic life.

With fish, the technologist has no striking success to his credit. For this, the original prodigality of the seas must be blamed. The pioneer farmers who opened up the prairies of the New World gave no thought to scientific agriculture and the preservation of soil fertility. Poor yields or wasted land were nothing to those who had a seemingly limitless area at their disposal. Today, in the same way as the prairie farmer finally recognised the exhaustibility of his resources, so have the more enlightened maritime countries—enlightenment is weak and flickering—begun to understand that there are limits to the fruitfulness of the ocean. When this truth is fully recognised, scientific technology may achieve a real success in dealing with fish. At least we can be assured that fish, the last of the wild creatures to be hunted by man as a staple food, will not be exterminated like the bison.

The record of useful achievement can be resumed when we consider technological developments in the handling of eggs. The productivity of the hen has been enormously increased by modern nutrition and breeding. There is, indeed, room for further progress in preventing completely the changes by which a stale egg makes itself apparent; and the process of dehydrating eggs, although highly successful, has been shown to give rise to a possibility of danger by disseminating infection unless the most stringent precautions are maintained.

Finally, the technologist has solved a difficult problem in enabling safe milk to be distributed throughout our modern cities. It is unfortunate that cows bred to produce the largest possible *quantity* of milk tend to produce milk of poor quality, unlike hens, of whom the most prolific egg-layers usually lay the best quality eggs. The technical control of fats possessed by the present-day manufacturer is one of the most striking advances of modern food processing. Whale oil, peanut oil, fish oil or olive oil can all be converted by the process of hydrogenation into the bland, white, almost tasteless foodstuff we know as cooking fat.

And so we could go on enumerating the triumphs of science applied to food. The question which may occur to the thoughtful reader is: Does the present command of scientific technological methods possessed by the food manufacturer give us 'good' food today?

The larger food manufacturers unquestionably maintain a consistent level of quality in the products they sell. The motives which stimulate them to achieve these standards are, firstly, honesty, and secondly, enlightened self-interest. The copy-book maxim that honesty is the best policy, though not, perhaps, a very lofty sentiment, is yet a potent stimulus to good behaviour in many walks of life; and when the public know that they can depend on a named brand of food always to reach a certain quality, the producer of the food can expect to maintain his sales and hence his profits. The third influence which tends to the production of good food by the technologist is the force of public control as manifest in the Food and Drugs Act and the many other regulations which today exist in all civilised countries. These not only prevent the sale of food grossly unfit for human consumption but also attempt to adjudicate on the subtle considerations by which it may be decided that the addition of nitrogen trichloride to flour is harmful but chlorine dioxide is not, or that *polyoxyethylene stearate* is harmful when used in bread, which is eaten every day, but not when added to ice cream which, it is assumed, is eaten less frequently.

The standards voluntarily maintained by manufacturers and those imposed by public health authorities alike are, each in their degree, influenced by the conscience of the period in which they are set up. The behaviour of both the public authority and the manufacturer can be swayed by expediency. For example, in the period before World War II it might be claimed that the public authorities favoured a higher standard for jam than was sometimes found on the market. After the outbreak of that war, however, the British Ministry of Food itself set up jam standards recognised as deplorable by discriminating housewives. It was influenced by much the same reason as the manufacturers of pre-war cheap jam: it was easier to obtain processed pulp than good fruit. A further striking example showing that good behaviour is not the exclusive possession of the public authorities is that of milk pasteurisation. We have discussed at some length the technical results of pasteurisation. It only remains to say that, at the date these words are written, although pasteurisation is not enforced by public authority, the large dairy companies supplying big towns pasteurise the milk passing through their hands.

Can we now answer the question whether modern food technology provides good food? The reply is that, since we are children of the age in which we live, we depend, for almost *all* our food, on the complex economic and technical forces which keep our civilisation going. This means that the quality of the food we eat is determined, in part, by those who manufacture, process and supply it, and in part by the public authorities who see that it is of the 'nature, substance and quality' demanded by their conceptions of purity and nutritional value. The most potent factor, however, is not the calculations of the manufacturer, nor the dictates of public authority, but the influence of the consumer. We have traced the scientific developments of food handling and processing, without which foodstuffs could not be brought to the tables of civilised communities in the quantity, variety and freshness accepted in the present-day as normal. The conclusion is that the food technologist makes supplies available. How 'good' the present diet is depends on the consumer's choice of them, and on how he combines, cooks and serves what he buys.

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